The Value of Electrical Treatment.

DR. JULIUS ALTHAUS.

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THE VALUE OF

ELECTRICAL TREATMENT.

BY

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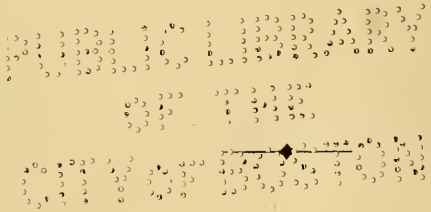

LONDON:

LONGMANS & CO., PATERNOSTER ROW.

1895.

June. 25, 1896.
A.

LONDON:
PRINTED BY WERTHEIMER, LEA AND CO.,
CIRCUS PLACE, LONDON WALL.

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The Value of

Electrical Treatment.

SINCE the appearance of the last edition of my "Treatise on Medical Electricity," in 1873, much quiet and useful work has been done in this department of science, more especially with the object of applying the more exact physical knowledge which we now possess of the qualities of electricity to the improvement of the methods of its medical application. Electrical measurement is at present far more precise than it was formerly, and the whole apparatus which is now habitually employed in electro-therapeutics is greatly superior to that which was in use twenty years ago. There has been no actual new departure, such as was inaugurated by the brilliant researches of Duchenne and Remak about forty years ago, if we except perhaps Apostoli's treatment of uterine tumours and hæmorrhage, which has excited a good deal of fanaticism and obloquy; yet, on the whole, there is doubtless much more definite knowledge and more extensive clinical experience than was formerly available.

In spite of this, it cannot be said that professional opinion about the value of electricity in the treatment of disease is now more settled, for a considerable amount of scepticism still prevails with regard to it. That this should be so appears to me owing to several causes. In the first instance, the truly outrageous quackery which has been

permitted to flourish in connection with medical electricity, without being in the slightest degree interfered with by the Medical Council or any other constituted authority, has cast a somewhat sickly glare on the subject, and created a prejudice against it in many minds. On the other hand, some advanced thinkers in Germany, such as Möbius and Moll, have started the peculiar notion that electricity in medicine does not act through its physical and chemical qualities as other remedial agents do, but simply through suggestion—the fad of the day; and the boldness and ingenuity with which such flighty arguments have been brought forward, have recommended them to the favourable notice of many who were not well informed on the subject. Several influences have therefore been at work to undermine the professional estimation of the value of electricity in therapeutics.

On the other hand, there is the indisputable fact that the use of it has now become a recognised branch of study and education in most English hospitals, which was not the case ten or fifteen years ago; while in Germany and the United States almost every practitioner makes daily use of both the constant and intermittent current in his treatment of disease. If electricity could not accomplish more than "Perkins's metallic tractors," or other imaginative therapeutical agents, it may be taken for granted that it would long ago have disappeared from practice.

Having been in intimate touch with this subject during a long professional life, it has, under the circumstances just mentioned, appeared to me worth while to submit once more to the profession my views on the uses and limits of usefulness of electricity in medicine. I have not touched in the following pages either on electro-physiology or electro-diagnosis, as no very important advance has for some considerable time occurred in these branches of the subject.

The forms of electricity which are at present utilised in medical practice are :

1st, electricity in the state of rest, or *frictional*, or *static*, or *franklinic*, electricity;

And 2nd, current or kinetic electricity, or electricity in motion, the two principal varieties of this latter being the continuous or *constant galvanic*, or voltaic or battery current; and *electro-magnetism*, or the interrupted, intermittent, induced, or *faradic* current.

Franklinic electricity was known and medically employed long before current electricity had been discovered, but lost favour when the striking phenomena connected with galvanism and faradism began to attract attention. Of recent years static electricity has however gradually crept back into practice, and is now considered to be a very useful addition to the electric instrumentarium. The induction or influence machines which have been lately constructed, and the best of which are those of Carré, Wimshurst, and Lewandowski, yield a plentiful supply of electricity independently of the weather, which in our damp climate is a very important consideration. They may be put into action either by turning with the hand, by electro-motors, or by gas engines.

Franklinic electricity is chiefly used in the form of a dry bath, the patient being charged while on an insulating couch or stool. In this way many patients in La Salpétrière, at Paris, are habitually charged with positive electricity for several hours a day. Franklinism is also applied by drawing sparks from round conductors; as the electric wind, or breeze, or douche, when a pointed conductor is approached to those parts which are intended to be acted upon; or a metallic cap, connected with a conductor, is held at a certain distance from the head. A discharge intermediate between the wind and spark is produced by the so-called "electric aigrette," when a blunt metallic point or a piece of wood is approached to the patient's body. Maclure has found this latter useful in cases where it is intended to act on a particularly sensitive part, such as the face, or as

preparatory for stronger treatment in timid patients. Finally, a "static current" has been employed by Morton and others, by passing an uninsulated metal ball rapidly over the clothing of the patient.

All these different modes of using franklinic electricity produce a mixture of stimulant and sedative effects on the system, which may be utilised in the treatment of certain neuroses, such as hysteria, hystero-epilepsy, neurasthenia, insomnia, and obstinate forms of neuralgia and spasm. Morton has recently used his "static current" in cases of locomotor ataxy and other degenerations of the spinal cord with apparent benefit, but more experience is necessary before a final judgment on this point can be formed. A drawback to this treatment is that it appears necessary to use powerful and painful discharges, which will preclude its employment in a number of cases, and which runs counter to the generally accepted principle that a mild application of electricity is, *cæteris paribus*, better than a severe one. As ozone or electrified oxygen is developed during the action of the franklinic machine, the patient may be made to inhale it by holding an insulated disc with a number of points at some distance from his mouth. This proceeding has been found useful in certain forms of anæmia and spasmodic asthma.

ELECTRICITY IN MOTION.

The Constant or Continuous Galvanic Current.

This is by far the most important form of electricity for medical purposes. Its effects have been better and more thoroughly studied than those of franklinism or faradism, and it has been shown to possess far greater therapeutical value than all other modifications of the force. It may therefore be said to be absolutely indispensable to those who wish to apply electricity in medical practice.

Ohms and Volts.

Ohm's law forms the base of all our knowledge of galvanic electricity. It is to the effect that the current-strength is directly proportional to the electro-motive force, and inversely proportional to the resistance encountered in the circuit of the battery; in other words, the current-strength is equal to the electro-motive force divided by the resistance. This may be expressed by the formula $C=\frac{E}{R}$.

A unit of resistance was first proposed by Werner Siemens in 1849, and defined as the resistance of a column of mercury one mètre long, and one square millimètre wide.

The British Association afterwards proposed their absolute unit (B.A.U.), which was called "ohm," and adopted by the International Congress of Electricians, which met in Paris in 1881. The Congress, however, modified the unit in such a way that at present an ohm represents a column of mercury 106 centimètres long and 1 square millimètre wide. An ohm is therefore equivalent to 1·06 Siemens unit. This is called a "legal ohm," in order to distinguish it from the real ohm, which has not yet been measured with absolute accuracy, but is about 0·3 per cent. less than the legal ohm.

The units introduced by the Paris Congress are called "absolute," a term first used by Gauss, who in connection with Wilhelm Weber reduced the magnetic and electric forces to units of length, mass, and time, without reference to arbitrary units. These original units were expressed in millimètres, milligrammes and seconds; but, at Paris, it was decided, on the proposal of Lord Kelvin, that the base of the units should be centimètre, gramme and second; and this is usually designated by the letters C.G.S. The Congress termed the unit of electro-motive force a *volt*; and this is of nearly the same value as the current given by a single cell of Daniell's battery. The exact value of that cell

is 0·9268 volts, and most of the other cells which are in use have similar values.

Ampères and Coulombs.

The unit of current-strength is called an ampère, which is therefore equivalent to $\frac{1 \text{ volt}}{1 \text{ ohm}}$, or in other words to the strength of a current produced by the electro-motive force of one volt in a circuit having a resistance of one ohm. As the ampère is too large for medical purposes, the thousandth part of it, or the Milli-ampère has been generally adopted. A current of one ampère passing for a second and doing work, *e.g.* in decomposing water, is called a *coulomb*. This is therefore the standard unit of measure of electrical work. Thus, if a current of one ampère has been flowing in a circuit for five minutes, we know that 300 coulombs of electricity have passed during that time. The quantity of hydrogen and oxygen liberated by the electrolytic decomposition of water, or the loss of water shown in a measured tube, will therefore show us the exact quantity of electricity which we may have administered to a patient during a sitting.

INSTRUMENTS REQUIRED.

The Battery.

A good galvanic cell should possess a high electro-motive force, say of 1 or 2 volts. It should have a low internal resistance, say of 0·5 to 1·5 ohms. Polarisation, which is inevitable in all batteries, should be reduced to a minimum, so that the nascent hydrogen which results from the decomposition of water, may at once combine with oxygen or chlorine; for if it were allowed to accumulate, the electro-motive force would be speedily diminished, and the battery would "strike"; while cells in which depolarisation is more or less perfect will last for years, if fairly used, without requiring attention. Finally, there should be no

spilling, or acid vapours, or other inconveniences connected with the use of the battery.

Only two batteries are at present generally used which fulfil the conditions just mentioned, viz. the Leclanché and the chloride of silver cell. In the Leclanché cell (invented in 1868) zinc and carbon are in contact with a concentrated solution of ammonium chloride and pyrolusite, or native peroxide of manganese, which acts as the depolariser. When the cell is in action, the ammonium chloride solution is decomposed, and the nascent hydrogen is absorbed by the oxygen of the pyrolusite, while chlorine combines with zinc, and ammonia is set free. The Leclanché cell is superior to any other where a stationary battery is required for the consulting-room, as it is very constant, provided the cells have a large surface. A battery which Mr. Schall has fitted up for me had lost very little of its electro-motive force after three years' almost daily and often prolonged use. A good dry cell is now made which is even more constant than the old liquid cell. The electro-motive force of the Leclanché is 1·48 volts, while its internal resistance varies according to the size of the cell from 0·4 to 1·5 ohms.

The *chloride of silver cell* consists of zinc, silver, chloride of silver and a diluted solution of ammonium chloride. Chloride of silver is the depolariser and forms chloride of zinc, while metallic silver is deposited in a finely pulverised state. This cell is, on account of its lightness, particularly suited for portable batteries, for depolarisation is very complete, and the cell can therefore be made very small without becoming inconstant. The original Warren de la Rue cell (invented in 1868), had an electro-motive force of 1·03 volts, while Scrivanow's modification gives 1·4, and Schall's as much as 1·61 volts, while the internal resistance is small. The recent modifications of this battery will remain in good condition for several years.

A battery giving from 40 to 60 volts will generally be found sufficient. It is useful to have it provided with a

so-called "double collector," which was invented by Gaiffe, and which permits the even use of all the cells, while the ordinary single collector has the drawback that the first cells of the battery are always used, and therefore suffer more than the last. The battery should also have a contrivance by means of which the direction of the current may be reversed in the metallic circuit.

The Rheostat.

In order to procure the finer shades of galvanic power, which are particularly required where the constant current has to be applied to the head or neck, and in sensitive patients, a well-constructed rheostat, by means of which the amount of resistance in a circuit may be varied *ab libitum*, is absolutely necessary. With the current-collector we are only able to proceed from one cell to another, while with a rheostat, or, better still, with a chain of two or three rheostats, small fractions of volts are placed at our disposal, and we are thus enabled to apply the current with the

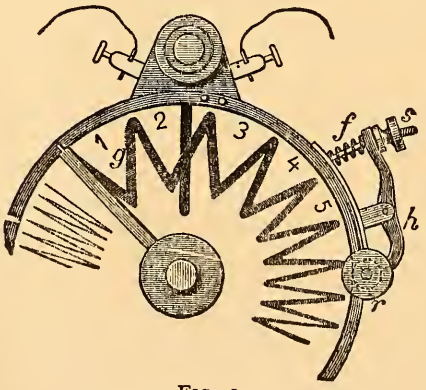

Fig. 1.

Lewandowski's Rheostat.

utmost delicacy so as to suit the special requirements of each individual case. Resistance coils are generally made of German silver wire, and are multiples of ohms, such as

5, 50, 500 ohms, etc. The best and most convenient rheostat for the use of the constant current in medicine is, however, that constructed by Lewandowski and Leiter, in which graphite and mercury are used. This instrument has an entire resistance of 100,000 ohms, and allows us to gradually diminish it down to 5 ohms, without the slightest break in the continuity of the current. To work with it is a real pleasure, which can be fully appreciated only by those who have previously employed the crude rheostats which were in fashion even five or ten years ago, and with which "jumps" or "jerks" were apt to disturb the operator as well as the patient.

The Galvanometer.

Another indispensable instrument is an absolute horizontal galvanometer, which will show not only the direction in which the current flows, but also the milli-ampèrage which may be passing through the patient's body. "A Milli-ampère is a Milli-ampère," whatever may be the condition of the battery from which the current is derived, or the individual susceptibility or resistance of the patient.

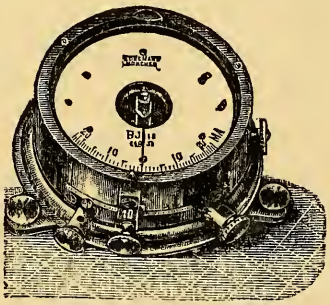

Fig. 2.

Edelmann's large Galvanometer.

The vertical galvanometer was formerly generally used, on account of its simple construction; but it was soon found to be unreliable, owing to changes which are apt to occur in the magnetism of the needle, while the magnet itself does

not change. Such one-sided changes do not occur in the horizontal galvanometer, which is therefore now almost exclusively used. The best instruments of this kind are Edelmann's "pocket" and "large" galvanometer.

The latter allows us to read off any current-strength between $\frac{1}{10}$th and 800 Milli-ampères, and is particularly useful in the modification suggested by Müller, of Wiesbaden, which is furnished with a vertical scale and index, by which the reading of the instrument is much facilitated.

The Coulombmeter.

With this instrument we can determine the quantity of hydrogen and oxygen resulting from the electrolytic decomposition of water in one second by the flow of one ampère.

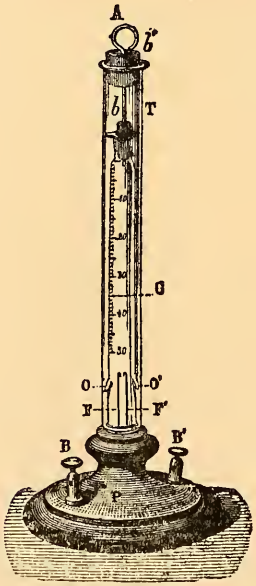

Fig. 3.

The Coulombmeter.

While, therefore, the absolute galvanometer shows the current-strength which may be passing at a certain time, the

coulombmeter shows us the electrolytic work which is being performed by the current in the tissues during a sitting. A few seconds after the application of the electrodes to the skin, that is, after the resistance is overcome, streams of hydrogen and oxygen are seen to issue from the platinum points at the bottom of the tube, and the loss of water which takes place during the application may be read off at the side of the instrument. We may thus determine the quantity of electricity which we may intend using by the coulombmeter, instead of by the clock, and finish the application when the number of coulombs which we may consider a proper dose, has been produced. Kellogg, who first utilised the coulombmeter in medical practice, has, however, shown that, while there is a definite relation between the number of coulombs developed during the sitting, and the amount of work done by the current in the tissues through which it has passed, the work is also materially influenced by the strength of the current employed, the vital resistance of the tissues being a factor which modifies the result, so that, for instance, 5 Milli-ampères used for ten minutes is not in all respects the same as 10 Milli-ampères used for five minutes. An analogous fact occurs with regard to heat, for a pint of water at 100° C. produces many effects which a gallon of water at 50° cannot produce, although the quantity of heat in the pint, as measured by the quantity of ice which it will melt, is actually less than that contained in the gallon. Anyhow, by the combined use of the galvanometer and the coulombmeter, the dosage given will be more accurately known than by each one singly, or by the mere use of an ordinary timepiece.

Rheophores.

The rheophores or conducting strings should be made of fine flexible brass or copper wire, and thoroughly well insulated. Many years ago I recommended to have the insulating material made of two different colours, so as to be able

to distinguish at a glance the positive and negative pole, and this has been pretty generally accepted.

Electrodes.

The electrodes or conductors are generally made of tin plates, which are covered on one side with sponge or chamois leather or flannel, and on the other side with india-rubber or oilcloth. A large number of differently shaped electrodes is necessary for the electro-therapeutist, and a description of them may be seen in any good instrument-maker's list.

Density of the Current.

A simple record of the current-strength in Milli-ampères does not show us the actual electric force which may pass through a tissue at a given time, and it is equally important for us to know the density of the current, that is, the quantity of electricity passing in a unit of time through a unit of transverse section. The density of the current is generally calculated for the "active" or "efficient" electrode, by which we intend to act on a certain organ; while the "indifferent" electrode only serves for establishing the circuit, and is not taken into consideration as far as this point is concerned. The latter, however, is for obvious reasons generally one of large surface.

The density of the current is therefore equivalent to the current-strength divided by the transverse section of the conductor, and is expressed by the formula $D = \frac{C}{T}$. Other things being equal, for instance, three times the current-strength can be passed through a certain part with electrodes of 30 square centimètres[1] than would be the case with a surface of 10 scms. When a current of 10 Milli-ampères is

[1] In the following pages the abbreviation "scms." is used for square centimètres.

passing through a surface of 10 scms., each scm. of tissue will receive 1 Milli-ampère, while if the surface is 30 cms. each cm. of tissue will only receive $\frac{1}{3}$rd of a Milli-ampère. It is therefore not sufficient, when describing a medical application of the constant current, to say that so many Milli-ampères were used, but it is equally necessary to state the superficial area of the electrodes which were employed.

Milli-ampèrage[1] and current density are thus seen to be of the most vital importance for all therapeutical applications of the current, just as posology is for the use of drugs. It is, therefore, perhaps to be regretted that, with regard to the dosage of electricity, such widely divergent views should at the present time be held by many of the most prominent workers in this field. On going through the extensive recent literature on medical electricity, and comparing the practice of different observers in this point, one feels indeed tempted to exclaim: *tot homines tot sententiæ.* I have, on the whole, seen no reason to depart in later years from the principle which I laid down in 1870 (second edition of my "Treatise on Medical Electricity," p. 318), and which was to the effect that "a feeble current used for a short time produces the greatest therapeutical effect. A current which is strong and painful to bear almost always does harm instead of good, and more especially when it is applied for a considerable time." Certain exceptions to this rule will be subsequently mentioned.

Amongst recent writers the two extremes in this matter are represented by Müller, of Wiesbaden, and Morton, of New York. The former has arrived at the result that the best dose for the majority of cases is expressed by the formula $\frac{1}{18}$, *i.e.*, a current-strength of 1 MA. for an electrode surface of 18 scms.; and this exceedingly low force he administers once daily for a minute or a fraction of a minute only! Morton, on the other hand, recommends for

[1] In the following pages the abbreviation "MA." is used for Milli-ampères.

the treatment of spinal diseases a dosage of 65 MA.'s, with an electrode surface of $1\frac{1}{2}$ by 18 inches, which would give the formula of $\frac{65}{54}$, or, comparing it with Müller's, of $\frac{21{\cdot}6}{18}$. In other words, he advises more than twenty times the dose recommended by Müller, and that not for a minute, or a fraction of a minute, but for ten or twenty minutes consecutively. Before ridiculing such differences of opinion, we should, however, remember that much the same thing happens with regard to the posology of drugs. There are many practitioners in this country who consider 2 grains to be an ample dose of iodide of potassium. The majority of neurologists, when prescribing the same drug, use habitually doses of from 10 to 30 grains. During a recent visit to the United States, I found that a dose of 120 grains is frequently given there to children, and considered as by no means excessive. Professional ideas on posology are therefore seen to vary quite as much as those on electrical dosage.

Just as in prescribing drugs, we must, when applying electricity, be to a great extent guided by our individual experience. For the brain I am in the habit of using a current varying, according to the individual susceptibility of the patient, from $\frac{1}{2}$ to 2 MA.'s, with a superficial area for the efficient electrode varying from 16 to 130 scms., so that the formula would be from $\frac{1}{32}$ to $\frac{1}{65}$. In treating spinal disease I usually employ, likewise in accordance with individual sensitiveness, a current-strength varying from 2 to 10 MA.'s, and an area of from 40 to 130 scms., which would give a formula varying from $\frac{1}{20}$ to $\frac{1}{13}$. The indifferent electrodes which I am in the habit of employing have an area varying from 40 to 200 scms.

On the whole it will be found advisable to give rather too little electricity than too much. In cases where there is much torpor a larger current-strength will be required; while where there is irritation, a smaller power will answer

better. The conductivity of the different parts of the body has also to be considered, less strength being required for the face and head, and more for the back and limbs, etc.

A further point of great importance in applying the constant current is the *length of time* for which it is to be used. As for current-strength and density, so for time, opinions vary considerably. Müller and Lewandowski are in favour of very short applications, that is, from forty seconds to one minute for the brain, and from one to three minutes to the spinal cord, while American observers prolong the application much beyond that. The short sittings advised by some electro-therapeutists have been severely criticised and ridiculed, and it has been stated that it is impossible to produce a definite effect by an application which lasts only a minute or a fraction of a minute. Such objections are, however, purely theoretical, and not founded on practical experience. In certain forms of asthenia of the brain, for instance, where mental work is distasteful or actually impossible, I have repeatedly seen that the application of a large cathode to the head with 1 MA. for one minute enabled a man to go through a good day's work without trouble or fatigue, or caused the exhaustion induced by a hard day's work to disappear. In other persons who are not very impressionable, longer applications are necessary for producing a definite effect; and I have for this reason long made it the rule to begin with short sittings, and to gradually prolong them wherever this should appear expedient. The young electro-therapeutist should remember that long applications to the brain have sometimes brought about the opposite effect of that which was intended, viz., drowsiness, fatigue, and a feeling of discomfort and depression, instead of briskness, exhilaration, and desire for physical or mental exertion, which we wish to produce.

Under certain circumstances the length of the application has to be considerably extended if we are to obtain really useful results. Long applications, continued for from fifteen

to twenty minutes, have appeared to me essential in the treatment of certain psychoses, and of paralysis agitans, and epilepsy. This does not appear to have been realised by Lewandowski, the author of the best recent work on the subject and a most skilful electro-therapeutist, who will not go beyond the traditional forty or sixty seconds for the brain. Experience has shown me that if the patient is very carefully and gradually brought under the influence of the prolonged action of the current, not only is no harm done, but results may be obtained which cannot be achieved in any other manner.

How often should the constant current be applied? In severe and obstinate forms of neuralgia it may be useful to have several applications in the day, while otherwise one application daily is ample. In the majority of cases three or four applications weekly are sufficient.

The length of time of a course of treatment must vary according to the nature of the affection. In fresh cases of neuralgia, muscular rheumatism, etc., two or three applications are often sufficient for a cure; but where the affection is of long standing, a month or six weeks may be required for obtaining a definite and permanent result. In some forms of hemiplegia, and certain spinal affections of very protracted course, such as locomotor ataxy, infantile paralysis, etc., several such courses may be given at intervals, and a continuance of the treatment should be more especially recommended when the first course is shown to have had an influence in improving the most troublesome symptoms, or in arresting the further progress of the disease.

A further essential rule is to apply the current *to the seat of the disease.* Where debility or paraesthesia in an arm or a leg are owing to central troubles, they will never be vanquished by electricity applied simply to the peripheral part where such morbid symptoms may be perceived. The diagnosis of the localisation of the complaint which may be under notice is therefore of cardinal impor-

tance for the successful electrical treatment of it; and *no one can be expected to apply electricity with benefit in a given case unless he is well grounded in clinical knowledge.* The electrodes must be placed in such a manner as to insure the passage of the current through the suffering structures. Thus, in a case of paraplegia from myelitis of the lumbar enlargement of the cord, the principal, and often the only, application will be to the diseased portion of the organ. This rule, however, cannot always be rigidly carried out, partly because it is sometimes difficult to strictly localise the focus of the affection, and partly because a symptomatic treatment is sometimes of considerable assistance, in addition to treatment directed to the actual seat of the complaint. Thus experience has shown that in hemiplegia we should not simply act upon the suffering hemisphere, but on the paralysed limbs as well. On the other hand, it is often useful in peripheral palsies to apply the current, not simply to the suffering nerve, but likewise to its nutritive centre in the bulb or spinal cord.

Müller, of Wiesbaden, has expressed these different rules by the axiom: *leve, breve, sæpe, et in loco morbi.*

Mode of Action of the Constant Current.

It has been frequently stated that we know nothing about the way in which electricity acts, and that it is therefore irrational to employ it in therapeutics. If such a principle were adopted, it would imply the abandonment of our most efficient drugs, of the mode of action of which in the system we know really much less than of that of electricity. No one has yet been able to find out in what way mercury or iodide of potassium produce an influence upon the different tissues of the body; yet, we know that these remedies if properly used have a powerful effect for good, and we therefore utilise them daily in the practice of our profession. With regard to the action of certain other

drugs, we have more definite physiological knowledge; yet clinical experience must always be reckoned with apart from physiology. When applying electricity to a patient, therefore, we must certainly be thoroughly acquainted with, and to a great extent be guided by, a knowledge of its physiological effects upon the different tissues of the body; yet clinical experience will always be the most important element in any success we may achieve. In operative surgery it is generally found that the mortality diminishes in proportion to the increasing experience of the operator; and similarly success in electro-therapeutics is generally found to be more marked as the practical experience of the operator is becoming larger. No amount of reading will give such experience; and as anatomy is only learnt by dissection, thus skill in electro-therapeutics can only be acquired by again and again applying electricity to patients whose cases may be suitable for such treatment.

The mode of action of the constant current is a very complex one, and although much of it is known, there is unquestionably much further knowledge concerning it to be gained. It is, however, a well established fact that *the structure and function, more especially of nervous and muscular tissue, may be profoundly modified by the passage of the current.*

Electrotonus.

Pflüger's researches on electrotonus which were made on frogs' nerves, but have been shown to be applicable to living men as well, appear to me to supply the key to the large majority of the therapeutical applications of the constant current. The latter when passing through a nerve, causes definite alterations in its condition, viz. a zone of increased excitability in the neighbourhood of the cathode—catelectrotonus—and a zone of diminished excitability in the neighbourhood of the anode—anelectrotonus, there

being a "point of indifference" between the two poles, where the excitability is unaltered.

The cathode, therefore, acts as a stimulant, and the anode as a sedative, and the so-called polar method of treatment is based on this fundamental fact. Pflüger also found that the action of the current is not confined to the portion of the nerve which is comprised between the two electrodes, but extends beyond them to some distance.

The conductivity of the nerve is always lessened in the anelectrotonic zone, and may be at last completely annihilated if the current is powerful and applied for a certain length of time. In such a case anelectrotonus will eventually predominate over catelectrotonus, so that the entire section of the nerve acted upon will show the phenomena of anelectrotonus.

Catelectrotonus originates at once on closing the circuit, while anelectrotonus is established only after the current has been acting for some time. Stimulation, therefore, takes place when the condition of the nerve is changed from normal to catelectrotonus, or from anelectrotonus to normal; in other words, when catelectrotonus appears and anelectrotonus disappears.

Clinical experience has shown that the influence of electrotonus is not confined to a nerve, but extends also to the *neurone* (Waldeyer). A neurone is a nervous unit, which consists

1st, Of the *grey nerve-cell* (*N C*, Fig. 4), in which the nerve-force is generated, and which is invariably multipolar.

2nd, Of the *axis-cylinder* (*a c*, Fig. 4) or nervous process, which may be motor, sentient or sensorial, and constitutes a single long nerve-fibre proceeding from the cell, which after passing on for some distance terminates in a number of very fine branches or terminal trees (*t t*, Fig. 4), all of which have a free end, and do not anastomose with others.

3rd, Of a more or less considerable number of *protoplasmic processes* (*p p*, *p' p'*, Fig. 4) or *dendrites*, which divide almost

immediately on leaving the cell into a number of different branches, and terminate with a free end between the dendrites of neighbouring cells. Thus there is nowhere any anastomosis between all these millions of nerve fibres, but

FIG. 4.

simply contact, and Golgi has rendered it probable that they serve for the nutrition of the grey cell. The three different structures just mentioned form therefore the nervous unit or neurone, and the whole nervous system consists of innumerable multitudes of neurones, which are

simply connected with each other by contact, and constantly act and re-act upon each other. The therapeutical effects obtained by proper applications of the constant current can only be explained by assuming that electrotonic effects are not confined to the nerve-fibre, but extend throughout the substance of the neurone.

The electrotonic or *modifying* effects of the current are produced chiefly by the so-called "*stabile*" application, which means that the electrodes are kept stationary on certain parts of the body. The polar effects are all-important here, and we have therefore to distinguish between the "active" and the "indifferent" electrode. The active one is that which is placed to the part in which we intend to produce either catelectrotonus or anelectrotonus, while the indifferent conductor, which only serves to close the circuit, may be placed on the sternum, the epigastrium, the patella or the feet. It is essential that the electrodes, after being thoroughly well moistened with warm water, should be applied to their different places *before the current is put on*, after which the rheostat is brought into play for effecting a very gradual entrance of the current. The current-strength is then slowly, and without any jerks, increased to that degree of milli-ampèrage which we intend using. The time of passage should now be carefully noticed, and after the application is over, the rheostat has again to be used, so as to effect a very gradual diminution of current-strength until the needle of the galvanometer points to zero. It is only then that the electrodes should be removed from their places of application. This mode of proceeding, which is very frequently neglected, is more particularly necessary when we apply the current to the head or neck, and want of attention to this rule may jeopardise all the benefit we may otherwise expect from the use of electricity.

The anode will therefore be made the active electrode where we have to do with the various forms of over-action, and where we assume an undue excitability of the affected

nerves or neurones. By its sedative effects, it tends to change this condition into the normal one, and may thus prove curative in suitable cases of hyperæsthesia, neuralgia, tinnitus aurium, muscular spasm and contractions, etc.

The cathode, on the other hand, finds its appropriate sphere of action where the excitability of a nerve or neurone requires to be increased, *i.e.*, in paralysis and anæsthesia. It must, however, be understood that these differences are not absolute, but that we must in all cases analyse very closely the actual condition of the nervous areas which are affected before proceeding to treatment. Thus it may happen that apparent over-action of certain neurones is owing to sheer debility, and consequent loss of control, and this is often therefore better treated by inducing catelectrotonus in them than anelectrotonus.

Stimulating Effects.

Electro-physiological researches have shown that the constant current is a powerful stimulant for all the different portions of the nervous system as well as for the muscles. Where these stimulating effects are required, various methods of using the current are at our disposal. We use: 1st, the stabile application of the cathode to the seat of the disease, for producing catelectrotonus; in addition to which we may, 2nd, use the labile; 3rd, the intermittent application, and finally, 4th, voltaic alternatives. The *labile* application is that in which one electrode is stationary, while the other (generally the cathode) is slowly passed over certain parts of the body, without being removed from the surface. The *intermittent* application is that in which one electrode is stationary while the other is put on, taken off, and put on again. Finally, the *voltaic alternative* is produced by effecting a reversal of the poles in the metallic circuit, while both electrodes are stationary on the skin.

Catalytic Effects.

This term was introduced by Remak, and intended to embrace several different modes of action. In the first instance we have here to do with the effects of the current on the *vasomotor nerves*. Both poles cause at first a contraction of the arterioles, which is presently changed into dilatation, allowing a freer circulation of the blood. A further action is the *electrolytic* one, whereby chemical changes are brought about in all the tissues which are traversed by the current, hydrogen and alkalies being attracted to the negative, and oxygen and acids to the positive pole. Chemical changes of this kind must in the nature of things be followed by structural and functional alterations. Finally we have the effects of *cataphoresis*, which means a flow of liquids in the direction from the positive to the negative pole brought about by the action of the current.

The catalytic effects of the current are chiefly utilised for the dispersion of tumours, and for the absorption of effusions in the sheaths of the nerves and tendons, the muscles, glands, joints, etc., and are believed to cause permanent histological and chemical changes in the parts submitted to their action.

For the production of catalytic effects the chief application is a stabile use of both electrodes, producing alternately anelectrotonus and catelectrotonus, care being taken that the part which it is intended to act upon is traversed by the current in as many different directions as possible, by frequently changing the position of the electrodes. To this should be added intermittent galvanisation of the nerves and muscles in the neighbourhood, and stabile galvanisation of the part which is looked upon as the trophic centre of the suffering part. This is called *indirect catalysis*, and is, by those qualified to judge, believed to

have a good influence on the circulation and the nutrition of the affected organ. For producing indirect catalysis we may also apply the current to the neck (so-called "galvanisation of the cervical sympathetic"), which is done by placing the cathode below the ear, in the stylomastoid fossa, and the anode either to the transverse processes of the 5th, 6th and 7th cervical vertebræ, or to the manubrium sterni. A good deal of cheap ridicule has been thrown on this mode of application, but the practical value of it is thereby not affected. I pointed out long ago, in my "Treatise on Medical Electricity," that it is impossible to localise the current in the cervical sympathetic of the living man, but that by the various proceedings used under that name, the base of the brain, the bulb, the upper portion of the spinal cord, the pneumogastric, the depressor, and several other important nerves, are influenced, and that it is therefore *à priori* probable that this proceeding should have a considerable therapeutical influence.

Central Galvanisation.

The modes of applying the constant current locally to the various organs of the body will be touched upon under each separate heading, but there are some methods by which the current is more generally diffused throughout the system, to which I think it more convenient to refer in this place. These methods are chiefly used in cases of general debility and rheumatoid arthritis. One of them is the proceeding known as *central galvanisation.* In this a large cathode, of from 90 to 300 scms., is applied to the hypogastrium, while the anode of about 30 scms. is successively applied to the forehead, the vertex, the occiput, the auriculo-maxillary fossa, the cilio-spinal centre, and the entire length of the spine. A current of 1 or 2 MA.'s or more is used in this manner for ten or fifteen minutes.

General Galvanisation.

Another proceeding is that which is more strictly called *general galvanisation*, and in which a gentle constant current is applied to the nervous centres, plexuses, and large nerve-trunks. The anode of about 30 scms. surface should be first applied to the cilio-spinal centre, stabile; it is then conducted to the side of the neck, the auriculo-maxillary fossa, and the manubrium sterni, the brachial plexus, and the median and ulnar nerves and their terminations, after which it is conducted back along the extensors of the forearm to the motor point of the radial nerve, to the brachial plexus and cilio-spinal centre, after which the current is gradually reduced to vanishing point. Both upper extremities are treated in this manner, after which the spine, the head, the abdomen, and the lower extremities are in a similar manner submitted to the galvanic influence. The application to each upper extremity should last about two to three minutes, to the head and spine about half a minute each, and that to the lower segment from two to three minutes each.

I am in the habit of employing a more convenient mode of general galvanisation in cases of general debility with very satisfactory results. A large cathode of 200 or 300 scms. is placed to the epigastrium, and a smaller anode of about 40 scms. to the cervical spine. The current is now turned on, and gradually increased until it reaches from 2 to 5 MA.'s, according to the special susceptibility of the patient. This is allowed to flow for three minutes, and is then gradually turned off. The direction of the current is now reversed, so that the anode is on the spine, and the cathode on the epigastrium, and the proceeding conducted as before. The application is finished by applying a cathode of 130 scms. with 1 MA. for one minute to the parietal region of the skull.

The Hydro-Electric Bath.

A further method of general application is the hydro-electric bath, the mode of action and effects of which were first properly studied by Eulenburg (1883). In this country Steavenson (1891) and Hedley (1892) have strongly recommended its use. The bath is preferably one of porcelain, or where expense is an object, of wood. In the latter case the inside should be painted with white non-metallic enamel. The electricity is introduced by metal plates, which may be fixed at the head and foot, or at the bottom and sides of the bath, and which have a surface of ten or twelve square inches. Where a plate is fixed at the head of the bath, the head, shoulders, and back of the patient should be protected from touching the electrode by a wooden rest, somewhat similar to a wicker fire-screen for chair-backs. The head of the bath is generally connected with the cathode. By far the largest portion of the current used is lost in the water, and only about one-eighth part of it traverses the patient. The bath should be filled with plain water, at a temperature of about 98°. The addition of table salt or acid to the water, which is often done with the idea of increasing the effect, actually serves to diminish it, as the conductivity of the water is thereby improved, and more electricity is lost to the body.

The patient should enter the bath, and remain for a few minutes in it, before the current is turned on. The electricity is then let in very gradually, until the needle shows from 60 to 100 MA.'s. As the treatment proceeds, the strength may be gradually increased to 200 MA.'s, of which the patient would get about 40. After acting for about ten minutes, the current is carefully turned off until the needle is at 0, and only then the patient should be allowed to leave the bath. At the end of the performance he may have an electric douche for about half

a minute, which is easily done by connecting the douche with one of the poles of the battery.

The hydro-electric bath seems to be particularly effective when mineral water baths are used in combination with it. The beneficial effects of a combined electric and mineral water treatment have long been known in Germany, where Voigt, of Oeynhausen, Delhaes, of Teplitz, and Von Renz, of Wildbad, have carried out this plan. In England this treatment appears to be chiefly used at Buxton, where Armstrong is using both galvanic and faradic electricity in conjunction with the Buxton baths, which have long been favourably known for their good effects, more especially in chronic rheumatoid arthritis, even when unassisted by electricity. I had an opportunity of studying the Buxton water in August, 1894, and found that it is not so much allied to Wildbad and Gastein, as is frequently stated, as to Schlangenbad, through its containing silica, which imparts to these two waters the extraordinary velvety softness, which induced a Frenchman bathing in Schlangenbad to exclaim: "Ici on devient amoureux de soi-même!"

Electric hot air or vapour baths are used in the United States for patients who are unable to take the hydro-electric bath.

Faradisation.

Faraday's discovery of induction currents, in 1831, caused a new era in the medical employment of electricity. The use of the voltaic pile had at that time been completely abandoned; constant batteries for medical use were not in existence, and the striking phenomena produced with small and handy induction machines gave rise to the belief that at last the true medical electricity had been discovered. Duchenne's splendid researches on the effects of localised faradism on the motor nerves and muscles will for ever remain a monument to his genius; but the expectations held out by him that the induced current would be found

superior to other forms of electricity as a therapeutical agent, have not been fulfilled.

The electro-motive force of the induced current depends, 1st, on the strength of the battery current by which induction is produced; 2nd, on the power of the iron core which becomes magnetic under the influence of the battery current; 3rd, on the number of convolutions and the more or less perfect insulation of the coils of wire; and, 4th, on the distance between the primary and secondary coil ("Rollen-Abstand").

The primary current circulates in a comparatively short and thick wire, and the secondary in a thin and long wire, whereby their electro-motive force and resistance are modified; and these circumstances explain to a great extent why these two currents should produce somewhat different physiological effects. It is the fact that more powerful muscular contractions, especially in deeply situated parts, are produced by the primary current, whereas the sentient nerves of the skin and the superficial muscles are more stimulated by the secondary current.

Many faradic instruments which are manufactured are mere toys, and totally useless for medical purposes. The International Congress of Electricians, which met at Paris in 1881, recommended to the medical profession the use of Du Bois-Reymond's sledge-apparatus, which has been for many years employed in the physiological laboratory of the University of Berlin, as the pattern of what an induction machine should be, and this instrument should therefore always be used with preference, and more especially in researches where the results obtained by different observers have to be compared. The primary coil of this apparatus contains 300, and the secondary 5,000 convolutions of wire. The diameter of the short and thick wire is 1 millimètre, and that of the long and fine wire 0·25 millimètre. The resistance of the primary coil is 1·5 S.U., and that of the secondary coil 300 S.U.

Faradimeter.

Von Ziemssen and Edelmann have constructed a faradimeter for measuring the strength of the induced current in the same manner as that of the constant current is measured, with the rheostat and galvanometer. This is based on the fact that currents of very short duration produce the same effects whether derived from a galvanic cell or an induction coil, so that the rheostat and galvanometer may be utilised for measuring both forms of current. Lewandowski has introduced another ingenious instrument, in which the same object is obtained by altering the distance of one coil from the other, and by introducing resistances through the rheostat, when the galvanometer may be utilised for measuring the force of the faradic current.

Effects of Faradism.

The faradic current produces chiefly stimulating effects, which may be utilised for the skin, the cellular tissue, and the superficial muscles by using dry electrodes, more especially the wire-brush; while moistened conductors, similar to those used for the constant current, are employed when the more deeply situated parts are to be faradised. As this current has no chemical effects, it is on the whole more suitable for directly stimulating the mucous membranes than the constant current, which latter tends to cauterise such parts by its electrolytic action. The voluntary muscles may be faradically stimulated where they suffer from atony through disuse, as after fracture, dislocation, certain surgical operations, or permanent bandages, etc.; while the mucous membranes of the stomach and intestines may be faradised for dilatation of the stomach, intestinal palsy, and obstruction of the bowels. In atony of the bladder, nocturnal enuresis, and spermatorrhœa, faradisation of the affected parts has also frequently proved

useful. Faradisation of the skin by the wire brush may be used in cutaneous anæsthesia, for restoring the sensibility of the surface, and it may also act as an analgesic in different forms of hyperæsthesia, neuralgia, etc. The faradic current has little or no action in paralytic affections; on the other hand, we are able to cause certain effects on the brain and spinal cord by reflex action, through cutaneous faradisation continued for five to six minutes over the chest, back, and arms. It is believed that the bloodvessels of the brain and spinal cord may be contracted by this proceeding, and that revulsion from deeper parts which are congested may thus be produced. The attempt to make use of both currents combined (galvano-faradisation) has on the whole led to insignificant results only.

General Faradisation.

Just as the constant current may be applied to the whole surface of the body, the faradic current may be used by the medium of a bath, or by the proceeding known as "general faradisation." This latter proceeding is very popular in America; and has only one objection, viz., that it is somewhat tedious to carry out. A cathode of large surface is applied to the soles of the feet, or the patient is made to sit upon it. The anode may be either the doctor's hand, or a moistened plate of at least 30 scms. surface. This is successively applied to the forehead, the closed eyelids, the ears, the sides of the neck, the larynx, the lower portion of the cervical spine corresponding to the cilio-spinal centre, the other portions of the spine, the limbs, and the chest and abdomen. The current-strength should be slight for the head and neck, and greater for the other parts. Such an application should last from fifteen to thirty minutes, and may be repeated daily or every other day.

I now proceed to consider the principal conditions in

which treatment by the various forms of electricity has been shown to be useful.

General Debility.

Cases frequently come under our notice in which, without any actual disease being discoverable, there appears to be a want of tone throughout the system. All our organs are, when in their normal state, in a state of moderate tonic excitement, enabling them to fulfil their functions in a proper manner, without our being at all conscious of the processes which are carried on in them. This normal balance of the system which constitutes health, is apt to be lost in those who have a bad inheritance, a constitutional fault, or who have been subject to acute infectious diseases, such as influenza, diphtheria, scarlet fever, etc., or who have suffered from chronic diarrhœa, hæmorrhage and other exhausting discharges, or who have been subject to want, long confinement, overwork, anxiety and worry. Such persons are often, without having any special disease, thoroughly out of condition, and all the functions of the body are then sluggishly performed. Digestion is slow, constipation habitual, the heart's action weak, respiration without vigour, and any mental or physical effort distasteful and exhausting. They are indeed suffering from premature old age.

Such cases are often improved or cured by change of air and occupation, by sea-bathing, or a course of treatment at some French or German spa, by careful regulation of the habits of life, or a generally tonic plan of medical treatment. Where these and similar measures however do not produce the desired effect, the different modes of general electrisation (pp. 25, 30) may be used, and are frequently successful in restoring the disturbed balance of the system, and leading the patient back to health.

Old Age.

Health also habitually becomes impaired, without the action of any of the causes which I have just mentioned, in the natural order of things as age advances, and impaired nutrition generally leads to atrophy of the structures and organs of the body. The effects of old age are most pointedly seen in an impaired action of the voluntary and involuntary muscles. There is therefore difficulty in walking, standing, and maintaining the erect posture, diminished power of breathing, a feeble action of the heart, slow digestion, tendency to constipation, and diminution or loss of the expulsive power of the bladder. There is also much tendency to wasting of the mental centres, causing loss of memory, especially for recent events, and of the power of fixing the attention, and more or less indifference to the habitual interests of life.

In the debility of old age I have often seen a kind of revival taking place after a course of general electrical treatment, so that a person looked five or ten years younger, took again an interest in life, had assumed a more erect position, could walk a couple of miles where formerly a few minutes' exercise appeared to cause exhaustion, had a better pulse, a quicker digestion, and sounder sleep. This action of electricity appears to me to be chiefly owing to its stimulating influence on the vasomotor system of nerves, in consequence of which the arterioles become slightly dilated, thus causing a better circulation of blood in, and nutrition of, the structures of the body.

An officer, aged 70, had been tolerably well until he had had to undergo an operation for stone in the bladder. After this he seemed to age rapidly and had become very helpless. He had great difficulty in getting up from a chair, more especially from a low seat, could hardly crawl along and was very shaky in standing. The pulse was 60, and of low tension. He seemed to be utterly indifferent

to everything, and was only with difficulty persuaded to consult me. When I examined him, I found no actual disease, but the signs of senility, more especially in the nervous and muscular systems. The knee-jerk was so sluggish that I could only elicit it by the aid of Jendrassik's manipulation. Dynamometer = 0° in the right and 25° in the left hand, which had always been the stronger of the two. I subjected him to modified general galvanisation, and after a month's treatment he seemed quite a different man, held himself erect, could walk, stand, and rise from a chair much better, and took again an interest in his concerns. When the treatment was discontinued, the knee-jerk was almost normal, and the dynamometer showed 30° in the right, and 45° in the left hand.

Failure of Brain Power.

I have so recently [1] treated fully of this subject that I will in this place only say that failure of brain power, which is often called neurasthenia, is one of the most frequent disorders nowadays met with in practice, and is characterised by an absence of sustained mental and physical vigour, fatigue of body and mind being readily induced by comparatively slight efforts; while sleeplessness, depression of spirits, exaggerated self consciousness, and morbid feelings of terror and alarm disturb the tenor of life. Although the brain unquestionably suffers in these cases, yet there is no organic disease of it to which these troubles could be referred. It will be seen that "general debility" and "failure of brain power" are closely allied; the chief difference between the two conditions being, that in the former there is sluggishness in all the functions of the body, while in the latter the symptoms are more particularly referable to two different conditions which may co-exist

[1] "On Failure of Brain Power (Encephalasthenia), its Nature and Treatment." Fourth Edition. London, 1894.

with one another, and which may be defined as paresis, or want of action, and as undue excitability, or over-action, in the different functions of the brain.

Such symptoms occur not only in the intellectual sphere but also in the speech area, the sensory-motor tract, the centres of the special senses, and more especially in the bulb, where the cardiac, vasomotor, respiratory, renal, and other centres may suffer from want of action or over-action. In the various phases of this affection we often gain truly brilliant results from a carefully measured application of electricity to the suffering part.

It is highly interesting to observe in well marked cases of failure of brain power how completely the highest mental functions are dependent upon the physical condition of the hemispheres, and how very automatic is after all the mode of action of the latter. The influence of what we call "free will" is seen to be frequently inefficacious in stimulating the hemispheres to intellectual efforts, while these latter are rendered easy when by the action of the constant current on the vasomotor nerves sufficient arterial blood is provided for their nutrition, and a healthy action of the mental centres is no longer impeded.

A short time ago I was consulted by an author, aged 50, who had been engaged for some months in the composition of an important work which he intended to bring out. It was not half finished when he was seized with such utter distaste for literary labour that any attempts to write "made him sick." He found that he had no flow of ideas, and would sit for hours at his desk trying to compose coherent sentences, and then tear the leaves into strips and throw them into the waste-paper basket. The only thing he felt fit for was to read trashy novels, and they very soon wearied him; in fact he felt so stupid that he thought his literary career was at an end.

I treated him with 1 MA., applied by a flexible cathode of 135 scms. to both hemispheres, for one minute. After

two such applications he felt more desire to work, and commenced looking over a portion of his manuscript which he had written some months ago, but felt himself presently and almost unconsciously seized by the real ardour of writing, and finished twelve pages straight off, with a facility which reminded him of his best days. On reading over what he had written, he found the matter excellent, and far superior to anything he had done lately. His *magnum opus* is now nearly finished, and is so good that it is sure to increase his reputation. Thus a slight dilatation of the arterioles of the "mental centres" (Flechsig), and consequently a somewhat more abundant supply of arterial blood to the cineritious matter, which was brought about by the short passage of the constant current, was more effective in restoring the creative powers of the mind than the most determined efforts of his will had been before.

Failure of the Singing Voice.

An interesting fact, which, as far as I know, has not been noticed before, is that in cases where there is want of vigour in intonation and singing, without any local trouble in the laryngeal mucous membrane or other portions of the throat and windpipe, an application of electricity to the laryngeal centre has a remarkable influence in steadying and strengthening the singing voice. The laryngeal centre has, by Horsley and Semon, been shown to reside in the lower third of both Rolandic convolutions, close to the speech centre, and appears to suffer not unfrequently from failure of power, usually in consequence of over-exertion or depressing influences in general. In some cases of this kind electricity had already been applied to the throat, evidently through a misapprehension of the seat and nature of the trouble, and therefore ineffectually. Failure of the singing voice is a serious drawback for professionals, whose success in life depends upon their being in perfect posses-

sion of their vocal means; and in the nature of things no local treatment of the throat, which is often in perfect condition in such cases, can have the desired effect. The induction of catelectrotonus of the laryngeal centre is in such cases followed by admirable results. 1 to 2 MA.'s should be used for two minutes, with an active electrode of 140 scms. In very obstinate cases the application may be prolonged for five minutes.

Mental Affections.

Numerous observations by competent authorities in psychological medicine have shown that careful applications of electricity, and more especially of the constant current, are frequently followed by good results in mental affections. It stands to reason that cases of long standing and in which organic disease may have become developed, have only slight chances of being permanently benefited; while recent cases, where no structural change in the brain has taken place, are much more promising. Where we have to do with chronic meningo-encephalitis, with wasting of grey cells, proliferation of connective tissue, and other pathological changes, such as are seen more especially in general paralysis of the insane, electricity, even if most judiciously used, can do no more than relieve symptoms, such as insomnia, headache, obstinate constipation of the bowels, etc., and it may also remove neuralgia, paraesthesiæ of different kinds, and improve the circulation in the abdominal viscera and the extremities, where there is much tendency to passive congestion. Such treatment is of course more likely to be useful where there is no evidence of organic disease, and the mental derangement consists either of mental over-action and excitement, or deficient action and a depressive state. For undue excitability we should therefore produce anelectrotonus, and for depression, melancholia, and stupor, catelectrotonus of the mental centres.

Flechsig's most recent researches on the development of the myeline sheaths have shown that the mental or thinking centres, as distinguished from the sensorial and sensory-motor spheres in the cortex, occupy four large and well-defined areas in the human brain. These are, 1st, the præ-frontal area, situated immediately above the eyes; 2nd, a large portion of the temporal lobes; 3rd, a considerable area in the posterior parietal region; and 4th, the island of Reil. Morbid irritation of these areas leads to confusion of thoughts and insane delusions; paresis of them causes depression and melancholia; while their destruction, which takes place in general paralysis, is followed by loss of knowledge, experience, principles, and the higher sentiments, with inability of utilising the past, or of foreseeing the consequences of actions.

The relative value of these four mental centres is not yet known, but there can be little doubt that in the most complex mental operations they are all acting together. In the electrical treatment of mental affections we must therefore be careful to pass the current through the four areas mentioned above. Particular care is here required, as a strictly stabile application without any break in the steady flow of the current, is absolutely essential for doing good. Flexible, large-sized and thoroughly moistened electrodes should be applied to the fore-brain, and the temporal and parietal lobes, the current passing longitudinally, transversely and diagonally through the parts. This operation is much easier in bald persons, or where the hair is very thin, than where the hair is thick and abundant. In the former we generally notice a deflection of the needle of the galvanometer as soon as the current is put on; while in the latter several minutes may pass before the needle will move. It is therefore of the greatest importance to watch the galvanometer very carefully, as the current is only effective from the instant the needle is seen to move, and the time has therefore to be taken from that point, and not from the

moment when the electrodes have been applied. For this reason it is not permissible to attempt to galvanise the hemispheres without an absolute horizontal galvanometer being enclosed in the circuit, as otherwise one would not know what one is doing.

As a current of some strength overcomes the resistance of the hair much more quickly than a feeble current, such as we intend to pass through the cineritious substance, we may put on a much stronger current at first than we intend using, and then watch the galvanometer very carefully, so as to be able to reduce the current-strength at once as soon as the needle is deflected, taking care that not more than 1 MA. may be passing. If a feeble current is put on, and if the hair should happen to be thick and dry, five or ten minutes may elapse before the first deflection is obtained.

In cases of deep depression and melancholia it is best to resort only to catelectrotonus, and have the anode at a point of indifference. On the other hand, anelectrotonus should be induced where there is undue excitability, and the cathode should then be placed to a point of indifference, *e.g.*, the hand, the sternum, etc. Where there is any doubt about the kind of pole which should be used, I prefer to induce first anelectrotonus, then turn the current off, and induce catelectrotonus, one electrode being on the cervical spine, and the other successively on the frontal, temporal, and posterior parietal area.

The time during which the current should pass in the cases under consideration is of the greatest importance. The rule I follow is, to begin with a short application, say one minute, and then, as the patient becomes accustomed to, and tolerant of, the current, gradually to prolong the application until twenty minutes are reached. This is much safer than to begin with a long application. The current-strength should rarely exceed 1 MA.

A single lady, aged 44, had suffered from delusional insanity, and had been four months in a private asylum.

As the delusions left her, she was discharged, but continued in a state approaching dementia. I had some years before treated her with electricity for a severe form of chronic rheumatism, and as the treatment had been rapidly successful, her friends wished to know whether her mental condition might possibly be improved by the same means. When I saw her she appeared very listless, was unable to read or otherwise to occupy herself, and everything had to be done for her as for a child. She appeared to have a difficulty in understanding questions, and the only information which I could at the first interview extract from her was that "her head was very bad." Her physical health appeared to be good. I gave her 1 MA. through the præ-frontal region for one minute with an electrode of 130 scms. surface, and then sent the current transversely through the mid-brain for another minute. Two days afterwards she came again, and was quite talkative. She told me that her head was now a great deal better; the electricity had cleared it at once; she had felt herself again able to think, and on taking up a book, had been delighted to find that she understood what she was reading. I repeated the application, and next time she told me that she had felt so happy afterwards that "she could have danced all down the street with joy." She began again to take an interest in life, and spent hours in milliners' and drapers' shops, while previously she had evinced the utmost indifference to her dress and general appearance. With all this there was no undue excitability, and she appeared to have herself perfectly in hand. She had altogether seven applications at that time, and came back for another course six months later, when she had felt a slight return of her previous symptoms. She then had three weeks' treatment, at the end of which she appeared to be perfectly well.

The good effects of electricity in mental affections are unfortunately not always so rapidly produced as they were in this case, for in some patients two or three months'

treatment is required to produce a favourable result. Depression, melancholia, post-epileptic and hysterical insanity, the delirium of persecution, and delusional and confusional insanity may be treated with electricity with a fair chance of success. Galvanisation of the mental centres will probably be found to be in general the most effective proceeding; but we may also resort to central and general galvanisation and franklinisation; while in cases of deep depression, faradisation of the skin and muscles may be combined with the same. Benedict has seen good results from the constant current applied to the spine.

In taking leave of this subject, I feel that I cannot do better than quote the words of Arndt, about the necessity of certain qualities for those who undertake the difficult task of treating the insane with electricity. He says that "electricity is an excellent remedy in the treatment of insanity, but in order to be successful with it, great care, patience, and confidence are required—qualities only found in a man convinced of the final efficiency of his treatment. Mere attendants, nurses, or assistants, who simply do what they are told, and because it is their duty, will never have the success of a medical man convinced of the efficiency of electricity. We have cured patients who had been treated in vain elsewhere. We must likewise not give up treatment too early. Cases are on record in which the effect of the electric treatment became visible only after weeks, and in which it had to be applied again from time to time for months until at last the patient recovered."

Hysteria.

Hysteria is at present looked upon more as a psychosis than as a neurosis, its characteristic feature being a disorder in the lower levels of the mind, that is, in sentiments, moods and impulses, as distinguished from sustained attention,

consecutive thinking, and volition. It may therefore be treated by applications of the constant current to the mid-brain. I have in some cases found transverse galvanisation of the mid-brain, with the alternate induction of an- and catelectrotonus, exceedingly useful. The faradic brush has long been used for the treatment of hysterical anæsthesia and hyperæsthesia, and is frequently of great service in such cases; and the Franklinic bath and sparks are likewise appropriate.

Hemiplegia.

This most common form of paralysis is generally owing to hæmorrhage in some portion of the motor tract, between the Rolandic convolutions and the bulb; or to embolism of the middle cerebral artery; or to thrombosis of cerebral bloodvessels. Some loss of brain substance is the almost invariable consequence of an attack of hemiplegia; and the further progress of the case depends upon the extent to which the motor tract may have been damaged. Late rigidity of the paralysed muscles is the principal unfavourable symptom in these cases, as it shows that secondary sclerosis of the pyramidal tract has followed the original lesion. Where late rigidity is marked, little can be done to improve the patient's condition; yet electricity may even then do a certain amount of good. In some cases there appears to be a great disproportion between the nature and extent of the lesion, and the degree of the paralytic symptoms which may be present. The paralysis, and where the right side is affected, the concomitant aphasia, may be of a severe kind, and yet yield to a considerable extent to careful electrical treatment. In such cases we must assume that shock to the brain during the attack of apoplexy has had as much, or even more, to do with the paralysis than the actual lesion which has taken place. The best cases for treatment are those where the paralysed muscles are flaccid, and the tendon reflexes only slightly or not at all exaggerated.

I have, in my "Treatise on Medical Electricity" (third edition, p. 508), described the case of a clergyman who had, at the age of 46, suffered from aphasia and right hemiplegia, and was quite disabled when he came under my care. A month's treatment restored him to such an extent as to enable him to resume his work in a very large parish. I have seen him since then from time to time, and he has continued in very fair health. When I last saw him, in February, 1894, twenty-six years after the attack, he was able to work all day long, his mental faculties, more especially his memory and power of application, being very good. His speech was fluent, although long conversation was apt to fatigue him. Considering that he was then 72 years of age, his intellectual vigour was indeed remarkable. He squeezed the dynamometer with the right hand, which had been paralysed, up to 108°, and with the left to 120°, showing that some loss of power still existed in the right side, for 120° with the left hand usually corresponds to 140° with the right. There would thus be a deficiency of 32° in the right hand. The deep reflexes of the right upper extremity were only very slightly increased. The hand was fairly useful, as he could button his clothes, carve a joint, and write a letter, although certainly not with the same ease as before the attack. He was able to walk well, and did not drag the right foot on the ground. The knee-jerk on the right side was about equal to that on the left, and there was no ankle clonus.

I have treated a very large number of similar cases with both forms of current, and found that perfect recovery is most exceptional. Considerable improvement occurred in about 40 per cent. of the cases, and slight improvement in about 30, while in the remaining 30 no beneficial result was obtained.

Independently of the paralysis, patients suffering from hemiplegia often complain of headache, feelings of pressure, coldness, fulness, emptiness and confusion in the head,

depression of spirits, and many other unpleasant symptoms, which frequently yield likewise to the treatment of electricity. The following modes of application should be used:—first and foremost the suffering hemisphere has to be treated by strictly stabile galvanisation, care being taken that the focus of the disease should be traversed by the current. Longitudinal galvanisation is here the best method. Where there is much headache and other symptoms of irritation, the influence of the anode should be chiefly utilised; but where there is more depression and torpor, the cathode is more appropiate. In a number of cases I have found it useful to apply successively the anode and the cathode, care being taken to turn off the current before the poles are changed. I begin with thirty seconds in one direction, and after this give the same time to the opposite pole. Then the current is used at the neck, likewise thirty seconds on each side. After this the paralysed extensor muscles of the arm receive a labile application of the cathode, forty passes being made from the shoulder down to the hand. The leg is treated in a similar manner. After a time faradisation may be substituted for the constant current, the wire-brush being on the whole more useful than moistened electrodes. The current-strength should be most carefully considered, anything powerful being injurious.

As the treatment proceeds, the stabile application to the diseased hemisphere as well as to the neck, should be very gradually prolonged, until five minutes are given to each part. Prolonged applications to the paralysed limbs however appear to do more harm than good, and the benefit which has been gained is sometimes lost by too frequent or powerful cathodal passes.

Paralysis Agitans.

This most distressing and disabling affection is generally looked upon as incurable. The only medicine which I

have found to do any real good in it is strychnine, which may be combined with arsenic. A systematic and exceedingly careful use of stabile applications of the constant current to the head and neck, however, does more good than anything else. I look upon shaking palsy as a neurosis of the Rolandic convolutions, and as the symptoms are more those of debility than of irritation, I am in the habit of inducing catelectrotonus in the motor portion of the cortex in such cases. A cathode of 130 scms. is applied to the parietal region of the skull, the anode being held on the hand which is most affected. Where both upper extremities suffer, the anode is first placed to one, and then to the other hand. I have found it best to pursue the same plan as in hemiplegia, viz , to begin with a very short application and gradually to prolong it, so that at last fifteen minutes are given to the central convolutions, and five to the structures of the neck. Here more than in any other affection the principle of using a feeble current must be most strictly adhered to. I generally use 1 MA., and never more than 1·5. I have seen cases where by brutal applications of electricity all symptoms had been aggravated, and the discomfort caused to the patient had been so great as to make him actually dread the word electricity.

The treatment, as described above, should be carried out daily for six weeks. In general I have found that long before this time has expired, and indeed often after four or five applications, the tremor becomes diminished, and the affected parts regain some degree of power. As the treatment proceeds, the statuesque expression of the face, and the staring look gradually give way to the former mobility of the features; the speech becomes more natural; the usefulness of the hand is much greater, so that a patient who has been unable to open the door, turns the handle without any trouble; the rigidity of the body becomes less, so that it is easier to turn over in bed; and the power of getting up from a chair and of walking in the proper way is

re-established. The course of the disease may indeed be arrested for years by repeated courses of the treatment described above.

Such results are however as a rule only obtained in private practice, and where the treatment is carried out by experts possessed of the requisite apparatus, perseverance and skill. In hospitals where electric treatment is often given over to persons who have only little special knowledge and less patience, not much can be expected of electrical applications to patients suffering from this most intractable disorder, unless the head of the department superintends each application himself.

Epilepsy.

In cases of epilepsy which resist treatment by the bromides, borax, and phenazone, careful stabile galvanisation of the cortex and the structures of the neck is a most helpful proceeding. In the ordinary forms of epilepsy, in which convulsive attacks occur from time to time, we assume discharging lesions more especially in the grey cells of the Rolandic convolutions; while in the "petit mal," where the attack consists chiefly of a sudden loss of consciousness, the mental centres appear to be particularly suffering. Both forms being owing to irritation, anelectrotonus of the different portions of the cortex should be induced. The principle of beginning the treatment with short applications and of gradually prolonging them, holds good in this neurosis as well as in paralysis agitans. The limit of twenty minutes, with 1 or 1·5 MA.'s, is thus presently arrived at. The first course of this treatment should extend to from five to six weeks, and another course should follow a month or two afterwards, if convulsive attacks should return. In patients who have been accustomed to take large doses of bromides or borax, it is advisable not to discontinue these too suddenly, but to prescribe smaller doses in the beginning of the electrical

treatment, and to drop them altogether only after the patient has had from ten to fourteen applications of electricity.

Diseases of the Spinal Cord.

The remarks which I made when speaking on hemiplegia, viz., that there is sometimes a great disproportion between the nature and extent of the anatomical lesion, and the clinical symptoms which are caused by it, apply equally to certain spinal diseases. It is of course understood that any actual destruction of the grey or white matter of the cord can no more be repaired by any form of electricity, than by any other remedial agent; but cases happen in which the structural alteration is comparatively slight, and where a judicious use of electricity may be of the most essential service in improving the impaired function of the organ, probably chiefly by the catalytic effects of the constant current.

Transverse Myelitis.

The principal symptoms of this intractable disease are paraplegia, anæsthesia, paralysis of the sphincters, and bedsores; while the tendon reflexes are increased where the dorsal portion is affected, and lost where the lumbar enlargement has been inflamed. Atrophy of muscles, and certain vasomotor and secretory symptoms, such as œdema, etc., are likewise often present.

No one would think of applying electricity in the acute stage of this disease, but in its later stages much good may be done by a careful use, more especially of the constant current applied to the seat of the disease.

The cord may be galvanised either transversely or longitudinally. In the former case one electrode is applied to the spinal column, and the other to the sternum or abdomen. In the latter case, one electrode is directed to

the cervical, and the other to the lumbar portion of the spine, or one is applied immediately beneath the other, when only a certain section of the organ has to be submitted to the galvanic influence. Another way of acting on the whole organ is, to apply one electrode to the top of the spine, and another immediately below it, and then after a time to move both or only the lower one further down the spine, thus making several "stations"; or one electrode, generally the cathode, is placed to the superior cervical ganglion of the sympathetic, and the other, generally the anode, is gradually conducted down the whole length of the spinal column. Otherwise the same rules obtain as those for galvanisation of the brain, viz., that the surface of the electrodes should be large, that they should be applied before the current is turned on, and that the strength of the latter should be gradually increased and again gradually diminished before it is turned off.

If there are points in the spine which are painful, or tender to touch or percussion, or where a moderate current is unpleasantly felt, such points should preferably receive the influence of the anode. The anode should also act more particularly on the seat of the disease. In some cases an alternation of the poles appears to be useful during the same sitting, proper precautions being taken to turn the current off before the change is made.

Short sittings are essential in the beginning of the treatment. For a transverse application one minute is at first sufficient; while when "stations" are made, from one to three minutes are given. The current-strength has to vary according to the peculiar susceptibility of the patient, and according to whether symptoms of irritation or atony are predominant. In the former case from 1 to 2 MA.'s are generally sufficient, while in the latter from 5 to 10 MA.'s may eventually be employed.

In transverse myelitis I have often found that the exclusive treatment of the seat of the disease acts better

than peripheral applications to the paralysed limbs or the bladder. The latter may cause unpleasant symptoms, such as pain in the back, twitches in the limbs, restlessness and discomfort, and increased debility in the limbs and the bladder. This is more particularly found where the case is recent. Where the greatest care is taken in applying electricity properly, the effects are mostly satisfactory.

A young lady, aged 21, had an acute attack of inflammation affecting the entire transverse section of the lumbar enlargement of the spinal cord, in February, 1890, during the height of the influenza epidemic which at that time prostrated the majority of the population. Having been quite well in the evening and gone to the play, she was in the night suddenly taken with shivering fits, and severe pain in the head, back and limbs. The temperature speedily ran up to 104°, and she had within twenty-four hours lost all power over the lower limbs, as well as the bladder and rectum. Bedsores soon began to form over the sacrum, and at the heels, and anæsthesia up to the waist was established. I first saw her in April 1891, when some degree of recovery had taken place in the left half of the spinal cord, this being indicated by some return of motor power in the left thigh and leg, and of sensibility in the right lower extremity. There was muscular wasting on both sides, with complete loss of faradic contractility, and lessened response to the voltaic current (Re. Deg.), but the atrophy was much more marked in the right than in the left limb, there being an inch difference in favour of the left thigh, and $\frac{3}{4}$-inch for the left leg. Sensation and the superficial reflexes were completely lost in the left, while a slight degree of both was perceptible in the right limb. The deep reflexes were lost on both sides, and the bladder and bowels continued paralysed, there being incontinence of the urine with loss of expulsive power of the bladder, while the bowels could only be moved by means of enemata. The patient underwent successively treatment by

electricity, hypodermic injections of strychnine, and baths, and improved more particularly during the time that electricity was systematically used. A transverse application was made to the lumbar portion of the spinal cord, the anode of 130 scms. being applied to the seat of the disease, and the larger cathode to the hypogastrium. 1 MA. was used in the beginning for one minute, and the current-strength and length of time were gradually increased to 5 MA.'s and five minutes. At a later period, faradisation of the affected limbs by the wire-brush was added to this application. She has now so far recovered that the substance of the affected muscles is much firmer, and responds to both forms of current, while sensation and the superficial reflexes are almost entirely re-established. The knee-jerk is still absent on both sides, but the patient has recovered her motive power to such an extent that she can not only walk for two or three miles without assistance, but can go up and down stairs with ease, and can get on the top of an omnibus. The bladder has not entirely recovered, but she holds her water well during the day, and passes between four and six ounces at a time in the natural way. The action of the bowels is also much easier, and the period, which had become arrested, has returned and is regular. On two several occasions this patient had a long course of massage, by experienced masseuses, but without beneficial results.

Progressive Locomotor Ataxy.

In tabes the effects of a well-directed electric treatment are habitually good. In some of my cases all symptoms have disappeared, excepting the loss of the knee-jerk. Lewandowski states that in 10 per cent. of his cases even the knee-jerk returned. A stabile application of the current, with low strength and large electrodes, may be combined with stabile and labile applications to the suffering nerves of the limbs, with the use of the anode for tender

points, and galvanisation of the structures of the neck. Rumpf has used the faradic brush to the spine and limbs, the moistened anode being applied to the sternum, together with mercurial inunction in syphilitic cases, and has seen better results of the combined treatment than of inunction alone. This mode of treatment has however been somewhat disappointing in the hands of other observers, while a combined use of both currents has often been beneficial.

Paralysis of the ocular muscles, optic atrophy, deafness, anæsthesia, paralysis of limbs from neuritis complicated with tabes, paralysis of the bladder and lightning-pains, may be specially treated by local applications of the current to the suffering parts.

When speaking of the beneficial effects of franklinisation in tabes, Morton says that "he does not refer to the paltry administrations of small and toy influence machines. He has yet to see a machine too large for practical work. The smallest machine which in his opinion can be of real use, should at least possess six revolving plates, each being at least 26 inches in diameter. With such a machine thick percussive sparks from 4 to 8 inches in length can be administered over the spine, to nerve-roots and nerve-trunks, to the muscles, to paraesthetic areas. By such means a vigorous and very complete treatment can be carried out in about fifteen minutes. It is a concentrated electric current of enormous electro-motive force, at least 1,000,000 volts localised to the tissue immediately in relation with the disruptive discharge or spark. Electricity of this sort moves, displaces, distorts, and strains matter like living tissue, which suffers a condition of electric stress." No one will dispute the vigorous character of this treatment, from which Morton states to have seen excellent results.

In *acute ataxy after infectious diseases* the results of an electric treatment are often particularly good.

A gentleman, aged 57, married, had a severe attack of

typhoid fever in November, 1892. He was three months in bed, and had on several occasions hæmorrhage from the bowels. When he got up, he found that his intellect and memory were not so keen as before, that he had less self-control, was unduly emotional, and had difficulty in walking. When I examined him in July, 1893, I found symptoms of failure of brain power and ataxy in walking and standing. There was no muscular paralysis or anæsthesia, but he walked as if he were slightly intoxicated, could not keep the straight line, swayed in standing, especially with closed eyes, and felt giddy when coming downstairs, or when stooping. The knee-jerk was exaggerated and paradox, the leg, instead of being thrown forwards, making an excursion sideways. There was no ankle clonus. The urine was slightly alkaline, and contained an excess of phosphates. I treated him with from 1 to 5 MA.'s, with alternation of poles, and large electrodes to the spine for from one to five minutes; and after a time combined with this the faradic wire-brush to the lower extremities. The patient quickly improved, and after about a month's treatment the knee-jerk had lost its paradox and exaggerated character, and the power of walking and standing was fully re-established.

Spastic Spinal Paralysis.

In this affection, stabile galvanisation of the spine, more especially with the anode, yields good results when carefully practised. Labile applications to the affected limbs are to be avoided, more especially when the tendon reflexes are much exaggerated.

Infantile Paralysis.

The electric treatment of infantile paralysis is frequently disappointing, because it is not continued sufficiently long. With much perseverance, however, thoroughly good results

may be obtained. In this affection the cord should be acted upon in all directions—longitudinally, transversely, and diagonally, and with alternation of poles, chief attention being directed to the parts which are more particularly suffering, *i.e.*, the cervical enlargement where the arms are paralysed, and the lumbar enlargement, where one or both lower extremities are affected. In addition to this, the current should be applied to the structures of the neck, and to the wasted muscles with labile and intermittent applications. Faradisation by moistened conductors and the wire-brush, as well as galvano-faradisation are likewise useful. If this treatment is carefully carried out in recent cases for about twelve months, with occasional short pauses, partial or total recovery may take place.

Progressive Muscular Atrophy.

In both the spinal and the myopathic forms of this disease the various forms of electricity have been used in every possible manner, and a few cases have been reported in which improvement has followed. Unfortunately, electricity, however administered, seems in the large majority of cases utterly incapable of effecting a cure, or even arresting in any marked manner the further progress of these formidable maladies. Further trials, however, with Morton's static current and d'Arsonval's alternating sinusoidal current would appear desirable.

Spinal Debility.

Many persons, especially young women, suffer from such a degree of weakness in the back that they are to a great extent disabled, yet on examining them carefully no objective symptoms can be discovered. The electric tests are normal, there is no anæsthesia or paralysis or wasting, and the sphincters act well. In such cases a comparatively short galvanic treatment generally proves restorative.

A single lady, aged 43, had always been delicate. Her mother had been very ill previous to her birth, and died during labour. She was a seven months' child, and was not expected to live. She did not walk until she was three years old, and then only with steel supports, and could never run or romp like other children. As she grew up her walking powers improved, but when 20 years of age she over-walked herself when on a tour in Switzerland, and since then had been more or less of an invalid. Four years before she came to see me, she was ordered to lie on her back, and had done so until now. On examination I did not find any evidence of spinal or other organic disease. There was, however, great pain and tenderness in the spinal column and all the limbs, and any exertion appeared to be too much for her. The constant current applied to the spine, both transversely and longitudinally, had an excellent effect, for after a comparatively short treatment the patient was able to take a good deal of active exercise, had lost all pain and tenderness, and was greatly improved in her general health.

It is, however, *in peripheral nerve diseases*, such as local palsy and neuralgia, that the beneficial effects of electricity are habitually seen in the most striking manner. The principal method of treatment for local palsies is the use of the stabile cathode, and for neuralgia that of the stabile anode.

Neuritis.

In most cases of neuritis the prognosis is favourable except where the inflammation attacks highly specialised structures, such as the expansions of the optic and auditory nerves, which easily succumb to pressure by the effusion. The recuperative power of the ordinary peripheral nerves is very great, and the natural tendency of the disease is therefore towards recovery, so that slight cases often get well without any active treatment at all. In severe cases, on the other hand, the pain and tenderness in the inflamed

nerve, together with anæsthesia, paralysis, and wasting of muscles, may last for months or years without much improvement, and a judicious electrical treatment is then generally followed by excellent results.

Local Palsies.

One of the commonest forms of peripheral paralysis is *facial palsy*. I have treated a very large number of such cases, and cannot recall one in which considerable improvement or a cure was not effected by the aid of electricity. In the *Lancet* for March, 1891, I have described two cases of that much rarer affection, *bilateral facial paralysis*, in one of which the affection was apparently owing to the sting of a poisonous insect, while in the other influenza appeared to have caused the trouble. Both were in fact cases of multiple neuritis, as other nervous areas were likewise affected, and recovered completely under the influence of the constant current.

It has often been stated that treatment by electricity should be reserved for the later stages of this complaint; but my experience is to the effect that it is most useful when resorted to in the beginning. We may then call into play the catalytic effects of the current, and by doing so I have habitually seen a much more perfect recovery in the end than where the electricity had only been used some months after the occurrence of the paralysis. The principal thing here is the method of application, in which it is so easy to go astray. A powerful current is sure to do harm by aggravating the existing inflammation, while an exceedingly gentle force appears at once to ease the circulation and to reduce the pressure of the effusion. I am in the habit of using about $\frac{1}{2}$ to 1 MA., with the anode resting on the mastoid process, and the cathode below the stylo-mastoid foramen, so as to embrace the diseased portion of the nerve, for five minutes, after which a few

cathodal passes with the same current-strength are made over the paralysed muscles. There can be no question that this is useful, because the patient at once expresses himself as relieved of the unpleasant feeling of stiffness about the face, and because the muscles that have been acted upon are seen to do their work much better after the application. This latter result is more especially seen in the muscles of the eyelids, where the immediate beneficial effect is often very striking. Perseverance with this treatment for two or three months is, however, generally necessary for securing a permanent result. Occasionally I have found it useful, especially in long-standing and neglected cases, to apply the current not only to the suffering nerve, but also to its nutritive centre in the upper portion of the spinal cord.

Paralysis of the Deltoid Muscle.

This is generally caused by injury to, or inflammation of the circumflex nerve. I have treated an interesting case of neuritis of this nerve, owing to diabetes, in a merchant, aged 56, who, for the last eight years, had been subject to diabetes, which did not cause much thirst or polyuria, but was evidently responsible for a great diminution in his walking powers, which had existed all that time. Fourteen months ago he was suddenly during the night seized with severe burning pain in the right shoulder and elbow, which in spite of treatment continued for nearly three weeks. When the pain subsided the patient found himself unable to raise the arm, while he could bend the elbow and move the hand and fingers as well as before. He underwent treatment by electricity injudiciously applied, and by massage, for three months, but derived no benefit from either; and considerable wasting about the shoulder-top had been plainly perceptible for some time. On examining the right arm I found that it was hanging down apparently lifeless by the side, and could only be abducted from the body to a

very slight extent, in a direction forwards and outwards, but not at all backwards. The patient endeavoured to increase the extent of the abduction by calling into play other groups of muscles, raising the shoulder and stretching the wrist and fingers, but to no purpose. The very slight degree of abduction which could be performed was owing to the action of the supra-spinatus. The patient felt much inconvenience from this disability, being unable to wash and dress himself without assistance, to eat soup with his right hand, to light a gas-burner, to put his hand into his trousers pocket, etc.

The region of the deltoid appeared flattened, from atrophy of its substance, the skin was flabby, and its sensibility diminished. The electric tests gave the reaction of degeneration, viz., loss of faradic excitability, and lessening of voltaic response, the middle and posterior portions of the muscle being only excitable by a current of 15 M.A.'s, while the anterior portion gave a sluggish C.C.C., with 8 M.A.'s, the A.O.C. being barely perceptible. All the muscles in the neighbourhood of the deltoid were in their normal condition. The knee-jerk was sluggish, and the urine contained 2 per cent. of sugar. The case was therefore evidently one of acute neuritis of the circumflex nerve, which in the absence of injury, gout, syphilis, alcoholism, etc., had to be ascribed to the saccharine condition of the blood. The paralysis of the deltoid muscle was treated with faradisation of the skin by a soft wire-brush, and 6 to 8 M.A.'s, with 30 scms. applied to the deltoid muscle. After six weeks of this treatment, the patient having attended every other day, he was very much improved, being able to put his hand into his trousers pocket and to eat soup with his right hand. The treatment was continued for another two months and a-half, after which recovery was complete. The electric tests had improved *pari passú*, so that the anterior portion of the muscle responded well to 4 M.A.'s, and the faradic current

was effective in exciting contraction. The patient died four years afterwards of acute pneumonia, but had had no relapse of the paralysis at any time. A few hypodermic injections of strychnine had been made in addition to the electricity, but definite improvement had already set in before they were used, and as the patient disliked them they were not persevered with.

In the above case the treatment had to be continued for a considerable time, as the paralysis was complete, and not of recent origin. Where it is incomplete, the improvement under electricity is generally much more rapid. Such was the case of an officer, aged 27, who had dislocated his right shoulder twelve months ago by his horse falling over him. He had been unconscious for some time, but recovered fairly well, and had the dislocation reduced. Ever since he had had difficulty in moving the right arm up to the horizontal line, and suffered much the same inconveniences as the patient whose case I have just described. The paralysis, however, was partial, and the electric tests much better. He recovered the use of his arm after five applications of the stabile cathode.

Neuritis of the Brachial Plexus.

This affection is even more disabling than paralysis of the deltoid muscle. I have described a case of total paralysis and anæsthesia of the upper extremity owing to this form of neuritis, and in which I succeeded in completely re-establishing the use of the limb by electrical treatment, in the *Transactions of the Royal Medical and Chirurgical Society for* 1871.

Partial paralysis likewise occurs in this plexus in the form described by Duchenne and Erb, in which the deltoid, biceps, brachialis internus, and supinator longus are affected, and in Klumpke's form, in which the lower portion of the plexus suffers, when it is chiefly the small

muscles of the hand and the flexors of the fore-arm which become paralysed. The issue of such cases naturally depends upon the cause and extent of the lesion, but electrical treatment is in general indispensable for their cure.

Paralysis of the Musculo-Spiral Nerve.

This is a very common form of local palsy, and is generally owing to injury to the nerve where it winds round the humerus, and is therefore particularly exposed to the effects of pressure. In slight cases of this kind recovery ensues within a few weeks without any special treatment, but in the more severe forms of it, in which there is reaction of degeneration, the aid of the constant current has to be called in for overcoming the affection. E. Remak, who has studied this subject in a very able manner, has found that the best method of treatment is the stabile application of the cathode to the seat of the trouble, the indifferent anode being placed on the sternum. The cathode should have a surface of from 20 to 30 scms. The current is turned on after both electrodes have been placed in their respective positions, and is then very gradually increased until the patient feels that he is able to extend the hand more easily. This is generally the case when the needle of the galvanometer points to from 6 to 8 MA.'s. This proceeding should be repeated until perfect recovery is obtained.

Paralysis of the ocular muscles is generally owing to some central disease, which itself is mostly due to syphilis, diphtheria, alcoholism, diabetes, etc. Electrical treatment often fails to relieve this palsy, but occasionally proves useful even where it cannot remove the cause. The constant current is more effective than the faradic, a short and slight application being essential. It is important to act as much as possible on the seat of the disease, so that the mode of application has to be carefully considered in each individual case.

Some years ago I treated a case of *external ophthalmoplegia* in this manner, with unquestionable benefit. The patient was a gentleman aged 26, married, who had always been in bad health, and showed signs of inherited syphilis. He was quite suddenly taken, while at dinner, with paralysis of all the external muscles of the right eye, there being complete drooping of the eyelids and inability to move the eye in any direction. The iris and the ciliary muscle were unaffected, so that the disease seemed to be seated in the posterior portion of the nucleus of the third nerve. I passed the constant current with 1 MA. and 16 scms. for two minutes transversely through the supposed seat of the trouble, having the cathode on the mastoid process of the affected, and the anode on that of the opposite side; and afterwards made twenty slight cathodal passes over the closed lid. There was a plainly perceptible improvement immediately after this application, as the patient was able to raise the eyelid to some extent, and could move the eye a little way inwards. After four more applications the ophthalmoplegia had disappeared.

It is but fair to say that in two other similar cases which I have treated in a similar manner, no apparent benefit was obtained.

Direct faradisation of the paralysed muscles by very fine electrodes introduced into the conjunctival sac, which has been much recommended, seems to do more harm than good, and is now almost generally abandoned.

Neuralgia.

In the various forms of neuralgia electrical treatment is often successful after a great variety of other therapeutical procedures have failed to do good.

Neuralgic Headache.

By neuralgic headache I understand that complaint in which the headache constitutes the primary trouble, and is

not owing to coarse brain disease, hyperæmia or anæmia, alcoholism, increased arterial pressure, or other habitual causes of headache. The neuralgic headache, which is tolerably common, is generally found in persons with a neurotic inheritance, and comes on after the action of injurious influences, such as acute infectious diseases, mental anxiety, over-exertion, chills, etc. There are habitually no other symptoms excepting such as flow directly from the disturbance induced by the headache. The pain is more or less constant, but is liable to be greatly aggravated from time to time, so that true neuralgic paroxysms are set up. In such cases there is often no trace of a more general neurosis, such as hysteria, failure of brain power, hemicrania, etc., although a similar headache may occur as part and parcel of these conditions.

The neuralgic headache is often benefited by change of air and scene, by hydrotherapeutics, arsenic, and some of the modern analgesics; but where it persists after other modes of treatment have had a fair trial, no time should be lost in using the constant current, for many patients lose some of the best years of their lives through this trouble.

A lady, aged 21, had been quite well until she had scarlet fever, at 16 years of age, but had ever since suffered from severe headache, which had never left her for a single day. Both her parents had been highly nervous, and had died of paralysis; and her only sister suffered from great nervous irritability. The headache had, therefore, evidently been produced by a specific poison, in a person having a neurotic inheritance. There was generally a dull feeling in the forehead and vertex, but during the acute attacks which occurred frequently, the pain was of a shooting, throbbing, and stabbing character, and affected the entire head. The patient was thereby prevented from being in society, and from reading, painting, and following other occupations which she had enjoyed before. This had caused a complete alteration in her disposition, which had formerly been

bright, while she was now habitually irritable, and often hopeless and depressed. There were no objective symptoms, except tenderness in the forehead and the vertex, slight percussion of which sent a violent thrill through the head. She showed me a bundle of more than fifty prescriptions, from almost as many doctors, and appeared to have taken every medicine and applied every lotion which could reasonably be expected to do her good. I therefore abstained from further medicinal treatment, and resorted to the use of the constant current, placing a circular anode of 16 scms. successively to the tender points of the head, a cathode of 40 scms. being directed to the cervical spine. The current-strength used at first was 1·5 MA.'s, and the length of the application five minutes. The pain and tenderness were lessened by the first application, and after the current had been used twelve times, with somewhat increased strength and time of passage, the patient was quite free from the trouble which had afflicted her so long. Three years afterwards she informed me that she had had no relapse, and that she was leading a happy and fully-occupied life.

Tic Douloureux.

This, the most severe of all forms of neuralgia, likewise occurs habitually on a neurotic base, and may follow malaria, influenza, and other infectious diseases. It is sometimes benefited by the removal of certain causes of irritation in the eye, nose, or mouth; and in the slighter forms of it salicylate of soda, gelseminum, arsenic, and iodide of potassium are useful. Cases of maximum severity have been successfully treated by removal of the suffering nerves, and of the Gasserian ganglion (Rose); but before such operations are resorted to in apparently desperate cases, and also in all other forms which resist the usual treatment, I consider it incumbent upon us to use the constant current first, and to combine it, if necessary, with

the cataphoric introduction of cocaine or aconite into the suffering nerve, by means of anodal influence.

A married lady, aged 40, had suffered from strumous opacity on the right cornea, owing to scrofulous keratitis, when 8 years old. She had a neurotic inheritance on both sides, but had on the whole been tolerably well, when one day, after a long visit to a picture gallery, where she had been standing about in draughts, she was suddenly taken with curious little darts through the right eye and forehead. This went on for about ten minutes, and then subsided, but was the next day followed by more severe attacks, the pain in the eye being of a stabbing character, while the forehead felt as if it were bursting. After a time the attacks became more frequent, and every movement of the facial and masticatory muscles gave rise to a paroxysm, so that the patient avoided speaking and eating as much as possible. When the pain was particularly bad, she also felt a kind of spasm in the heart, the action of which became irregular and intermittent, with feelings of anxiety, oppression, and faintness. When I first saw her, two years after the commencement of the affection, the pain, although certainly not so overpowering as it is in the worst cases, was sufficiently severe to make her utterly wretched, and to destroy all pleasure in life. During the last six months she had taken unduly large doses of morphine, which was the only thing that gave her temporary relief. There was a tender point corresponding to the supra-orbital nerve, which I treated with a small anode, a cathode of 120 scms. being directed to the spine. The current-strength was gradually raised, and without shocks, from 0·5 to 6 MA.'s, and continued for fifteen minutes. The current was also sent transversely through the skull, so as to influence the Gasserian ganglion, for five minutes. After two such applications the patient expressed herself as relieved, and the tenderness of the supra-orbital nerve was less; but as there was still much distress, I now added

cataphoresis of a 20 per cent. solution of cocaine through the suffering nerve. The effect of the treatment was now more marked, and a satisfactory result was obtained in five weeks, at the end of which the neuralgia appeared to be subdued. The patient then remained free from pain for seven months, after which a relapse took place, which, however, at no time assumed the former severity. The treatment was at once resumed, and had again a favourable effect, ten applications being sufficient to afford complete relief. Twelve months afterwards I ascertained that the patient had enjoyed good health since the treatment was discontinued.

In some cases it has appeared to me advisable to use a very slight current-strength, viz., 0·5 to 1 MA., for thirty minutes and more. This is chiefly applicable to patients who are extremely sensitive to electricity.

Brachial Neuralgia.

The pathology of this form of neuralgia is closely allied to that of others, but different in this, that most cases have a hysterical base. The pain is often of a most violent character, but on the whole the affection is much more manageable than tic, and the prognosis is almost invariably favourable. With the aid of the constant current we succeed habitually in overcoming the neuralgia much more readily than in tic, and I have not found cataphoresis necessary.

A widow, aged 37, with pronounced neurótic inheritance, and who had at various times suffered from definite symptoms of hysteria, consulted me some years ago for severe pain and loss of power in the right arm. She denied having had a chill or an injury to the arm, and attributed the affection to mental anxiety and prolonged nursing of some sick relations. Soon after the last case which she had taken care of had got better, she felt, one evening about two months ago, a darting and shooting pain in the

right arm, and she thought she had broken it. Any movement of the limb increased the pain to such a degree that she felt obliged to keep it perfectly quiet. She had been very ably treated by an experienced practitioner, but did not get any better, and the pain continued so severe that she had had no sleep during the last two months, and was utterly worn out by pain and insomnia.

On examination I found great tenderness on pressure in the course of the musculo-spiral nerve, more especially where it winds round the humerus, and to a lesser degree over the lower cervical vertebræ. The skin of the arm showed a degree of anæsthesia, and there was loss of the sense of temperature, for the patient could not distinguish between heat and cold. This showed that there was a slight degree of neuritis, but there was no trophic disturbance and no paralysis. It is true that loss of power in the hand and fingers was complained of, and that the patient was unable to move the index of the dynamometer with the right hand, while with the left she squeezed it easily up to 90°; yet it seemed to me that this arose more from fear of increasing the pain by movements; and the further course of the case showed that this surmise was correct. The cathode of 64 scms. was now directed to the lower cervical vertebræ, while the anode of 40 scms. was placed over the musculo-spiral nerve, for five minutes, with 5 MA.'s, after which cathodal passes were made for three minutes in the course of the suffering nerve. There was no immediate effect after the first application, but four or five hours afterwards the patient felt much easier, and could move her hand and fingers a little without exciting a paroxysm; and she had that night the first real sleep for two months. After this she made further good progress, and had completely recovered after ten applications.

Another case in which the effect of stabile anodal galvanisation was very striking, was that of a celebrated actor, aged 52, who while staying abroad during very hot

weather, sat down in a cool place after a long walk in the sun, and was suddenly taken with most violent pain in the sphere of the brachial plexus. The pain was worst over the collar-bone, in the deltoid, and the terminations of the radial and ulnar nerves. Being then in the company of a most able physician, he was at once treated in the most appropriate manner; yet on his return to England nine weeks afterwards he was no better, but continued to suffer "downright intolerable pain." I found the clinical signs of slight neuritis. A single anodal application over the collar-bone, where there was much tenderness, stilled the pain at once, leaving a very pleasant feeling of a glow all through the limb. The patient recovered completely through a short treatment.

Intercostal Neuralgia.

This form of neuralgia is frequently complicated with herpes zoster, and is often very obstinate and severe. The pain is chiefly felt in the front and side of the chest, and there are habitually tender points near the vertebræ, in the axillary line, and close to the sternum. The causes are of a most varied character, and each case therefore requires a very special and careful examination, as the removal of the cause, wherever possible, is of the greatest importance. It is chiefly seen in young men and young women, and I have met with several cases which occurred after influenza. The principal mode of application is the stabile anode to the tender points, after which a few cathodal passes are useful. The affection generally yields to this treatment within a few weeks.

Irritable Breast.

This form of neuralgia occurs chiefly in middle-aged women, and is often connected with pregnancy, the puerperal state, and lactation. It sometimes appears on an anæmic or hysterical base, and may be connected with severe

hyperæsthesia, more especially in the region of the nipples. Tender points are habitually found on the spinous processes of the 2nd to 7th dorsal vertebræ, and should be treated by the stabile anode, after which cathodal passes are made over the breast. I have seen several obstinate and tedious cases, which yielded completely to this treatment.

Irritable Testicle.

This is generally consequent on gonorrhœa, and the pain is sometimes so severe that it disables the patient from following his occupation. The stabile anode, followed by cathodal passes over the affected testicle, habitually relieves the distress, but the treatment has occasionally to be followed for a considerable time, on account of the obstinate character of the affection.

Sciatica.

This is by far the most common form of neuralgia in this country, and occurs frequently in persons of a gouty disposition, or in otherwise healthy people after severe chills, more especially from sitting on wet grass after playing lawn-tennis, or after undue exertion in rowing, etc. One of my patients was an officer, aged 28, who had been "hunting the elk, moose, and grisly bear in the Rocky Mountains and Nova Scotia," and often got up to his waist into marsh-water, with only moccasins on. This eventually induced severe pain in the right hip and thigh, which assumed a neuralgic character, and darted into the leg and foot. Sciatica also occurs from diabetes, alcoholism, after acute infectious diseases, etc., but neurotic tendencies are far less influential in the production of it than is the case with other forms of neuralgia. In general, the clinical signs of a slight neuritis may be discovered, especially where the affection is of recent origin. In many of my

cases the pain had been incessant, and left the patient no peace either by day or night, thus causing insomnia and utter exhaustion of the nervous system; the pain being of a stabbing, boring, throbbing, or burning character, or like incessant pricks by pins and needles, etc. The worst time is often in the early hours of the morning, when the suffering may become so intolerable that the patient is obliged to get out of bed, and walk about the room for two or three hours together.

All experienced electro-therapeutists are agreed that electrical treatment does splendid service in most cases of sciatica, from whatever cause it may spring. Stabile galvanisation of the nerve by a large anode has appeared to me the best mode of treatment. Steavenson has advised labile galvanisation of the lower portion of the spine and the back of the thigh by the cathode, the anode being placed on the abdomen. In several cases which I have treated by this proceeding, the pain instead of being subdued, became more severe, and I have therefore given it up. Faradisation by the wire-brush, and also by moistened conductors, one being placed to the sciatic notch, and the other to the ankle, with a gradually increased current-strength, is likewise useful. The galvanic, faradic, and galvano-faradic bath, and the combined Buxton treatment (p. 27) also find here an appropriate sphere of action.

I have seen several cases of recently acquired sciatica in which a single application of the stabile anode permanently relieved the pain. Where the affection is of long standing, however, it is generally more obstinate, but is nevertheless curable by persevering electrical treatment, unless particular complications should be present, such as perimetritis, pelvic tumours, etc., which make against recovery.

A married lady, aged 33, had suffered from left sciatica for about twelve months, having been obliged to be in bed the better part of that time on account of the severity of

the pain, which was increased by the slightest movement. She had been treated with all the resources of the art by her experienced family attendant, as well as by the heads of the profession who had been called into consultation. It seemed occasionally as if the pain was about to yield to the remedies used, but it always returned shortly afterwards in its previous severity; and the patient was almost desperate when I first saw her, in May, 1880. Her health was in other respects good. The pain was chiefly felt on the left side of the sacrum, and in the course of the sciatic nerve from the notch to the knee, where there were several exquisitely tender points. That the pain in this instance was owing to neuritis, was evident from a considerable degree of analgesia which was present in the affected parts. The prick of a pin could not be perceived, and a current-strength which was plainly felt on the back of the right thigh, excited no sensation in the left.

There were from time to time convulsive twitches in the muscles supplied by the left sciatic; but there was no wasting, showing that the neuritis was not very profound. The anode of 30 scms. was applied successively to the left side of the sacrum, and the course of the nerve down to the knee. At first a very considerable current-strength had to be used, as owing to the analgesia the patient felt not the least effect from a moderate force. There was, however, an immediate improvement, and after three weeks' treatment she had completely recovered. No relapse has taken place at any time.

Multiple Neuritis.

The worst form of this disease is that known as *alcoholic paraplegia*, in which electrical treatment often affords great relief, yet rarely proves curative, because the patients, who are mostly middle-aged women, continue their drinking habits to the bitter end, in spite of all advice and supervision. Other forms of polyneuritis appear as so-

called "rheumatic" or "diphtheritic paralysis," and after influenza and similar occurrences.

"Rheumatic Paralysis."

A merchant, aged 56, married, had rheumatic fever ten years ago, and when recovering from it found that he had great difficulty in walking, having lost power particularly in the left thigh. During the twelve months before I first saw him, the trouble had considerably increased, in spite of treatment by strychnine, iodide of potassium, and baths. On examination I found slight anæsthesia in the left thigh, with wasting of the rectus, the left thigh being $1\frac{1}{2}$ inches less in circumference than the right. The knee-jerk was very sluggish in the left, but well marked in the right thigh, while the electric tests were fairly satisfactory. The patient had a difficulty in hitting out, and in crossing the left leg over the right, could not easily go up and down stairs, and was fatigued after a short walk. I made a stabile application of the cathode to the crural nerve in the groin, followed by passes, and faradisation of the skin with a soft wire-brush. After six weeks' treatment all the symptoms above described had greatly lessened; the knee-jerk was very nearly the same in both sides, and the walking power had so much improved that the patient could be on his legs "all day long" without fatigue.

A lady's maid, aged 40, had, after an attack of "acute rheumatism" three years ago, suffered from pain and loss of power in both hands and arms. She had great difficulty in doing her hair, in writing, working, and doing a variety of little things which require easy bending of the elbow. Thus she could not fasten her brooch, or carry a tea-tray. There was rigidity of the biceps, more especially in the right arm, and a degree of numbness in the limbs, with lessened electric responses of the nerves and muscles. Her wrists felt so sore that she could not wear cuffs. There was also numbness, pain, and loss of power in the legs. She was

treated with both currents, and it was found that the faradic wire-brush did her most good. After eight applications she was relieved of all her symptoms.

Diphtheritic Paralysis.

This is the most frequent form of multiple neuritis, which may follow slight as well as severe cases of diphtheria, and is on the whole more frequently seen in adults than children. There is generally paralysis of the soft palate, with nasal twang in speaking, and difficulty of swallowing, paresis of the oscular muscles, and of the laryngeal and cardiac nerves, with paralysis and anæsthesia in the lower extremities, and loss of the knee-jerk. The prognosis is throughout favourable, the only risk which such patients run being syncope from affection of the cardiac nerves. Those who escape a "bulbar crisis" (Guthrie) invariably recover from the paralysis with proper treatment.

A merchant, aged 53, had, in December, 1893, a slight attack of diphtheria, which "had been sent to him by post," as he had received a letter shortly before from a correspondent whose whole family was down with it; and the infection could not be traced to any other source. The local trouble continued for sixteen days, after which the throat was well, but two days afterwards he was seized with curious "tickling" sensations in the toes and fingers. The next day he lost power in the legs up to the knees, and in the arms up to the elbows. He consulted me three months afterwards, when there was anæsthesia, paresis, loss of superficial and tendon reflexes, wasting of muscular substance, and lessening of voltaic and faradic responses. There had been no paralysis in the palate, pharynx, larynx, or the ocular muscles at any time. The heart's action was satisfactory, and he had no trouble with the bladder and bowels, but the urine contained a small quantity of sugar. Walking without assistance was

impossible, and the character of the walk, when the patient was supported on both sides, partook of ataxy as well as paralysis. Severe pain in the extremities, with tingling and pins and needles, was likewise complained of. Although the patient was therefore quite disabled, I gave a favourable prognosis, more especially as the heart's action was normal, and the general nutrition of the body good. I treated him at first with stabile and labile applications of the constant current to the suffering nerves, to which, after a time, faradisation of the skin and muscles, and hypodermic injections of strychnine were added. A decided improvement however was noticed before the latter procedure was resorted to, and he eventually made an excellent recovery, as he was quite well about five weeks after the commencement of the treatment.

Spasmodic Diseases.

In these affections electrical treatment is as a rule not so effective as in paralysis and neuralgia; yet where other remedies fail, it may occasionally step in as the right thing in the right place. This applies to cases of facial and masticatory spasm, glosso- and blepharo-spasmus, general tic, writer's cramp and other professional neuroses, tetany, asthma, chorea, and analogous affections. The stabile anode with an exceedingly gentle force ($\frac{1}{2}$ to 2 MA.'s) should be applied as near as possible to the seat of the disease, the application being gradually prolonged from one or two to twenty minutes if required.

Tic Convulsif.

In April, 1885, I treated a case of this kind which was sent to me by Dr. Pletzer, of Bremen. The patient was a merchant, aged 40, single, who had been on the whole in good health, with the exception of a bad attack of scarlet fever when he was 21, during which the left membrana tympani was destroyed, entailing complete deafness on that

side. The first symptoms of tic supervened two years ago in the left side of the face. The eye was spasmodically closed from time to time, and the spasm gradually affected the whole side of the face. The patient had not had syphilis, and was in all other respects in perfect health. The constant current sent through the mastoid processes, with the anode on the affected side, 16 scms. and 2 MA.'s, for five minutes was effectual in relieving the trouble, and Dr. Pletzer has recently (January, 1895) written to me to say that the patient continues quite free from spasm. This form of tic is often treated with electricity applied to the suffering muscles, a proceeding which has appeared to me quite useless.

Cardiac Neuroses.

Where the heart's action is irregular and impaired through derangement of the inhibitory or accelerator system of nerves, electrical treatment may be of great assistance. This applies to *tachycardia*, *bradycardia*, *delirium cordis*, and the vasomotor form of *angina pectoris*.

A married lady, aged 25, had rheumatic fever and endocarditis six years ago, and had since been subject to mitral disease. This did not appear to cause her much trouble until about twelve months ago, when she had great domestic worry and anxiety. Since then she had been subject to distressing attacks, which generally commenced about 4 p.m. She then suddenly felt faint and frightened, had swimmings in the head, with great pain in the heart and left arm, and such severe palpitations that she felt as if she were going to die; she was covered with clammy sweat, and after a time almost collapsed. Such an attack would last till the next morning, when she gradually became more comfortable. She had been treated with digitalis, strophanthus, and nitroglycerine, but medicines appeared to have no influence on her condition. I directed the stabile anode to the pneumogastric nerve at the neck,

16 scms. and 1 MA., the cathode of 40 scms. being placed to the cervical spine, and allowed the current to pass for two minutes at each side. This treatment was followed for a month, and had the desired result.

Graves's Disease.

In August, 1875, I brought before the Annual Meeting of the British Medical Association, at Edinburgh, a highly interesting case of Graves's disease, in which the three cardinal symptoms of that complaint, viz., tachycardia, exophthalmos, and struma had been present, and in which I had succeeded in saving the life of the patient, which had been in the most imminent danger by a sudden and rapid growth of the tumour in the neck, by electrolysis of the enlarged thyroid body. The case is all the more important as the subject of it is now (April, 1895) alive and well, that is, more than twenty years after the treatment was discontinued, and has never had any return of the complaint. I therefore subjoin a few particulars of the same, and hope that it may lead to a more frequent recourse to electrolysis in this otherwise intractable disease.

J. L., aged 37, single, a native of Yorkshire, and engaged in a mercantile firm in the City, came under my care in April, 1874. He had for the last ten years been subject to a tumour in front of the left side of the neck, involving the thyroid body, which had very gradually increased until it reached an inconvenient size. There had also been a degree of exophthalmos and tachycardia. The patient had on various occasions consulted the heads of the surgical profession in London, with the view of having the tumour removed. This, however, was not considered expedient by the eminent men whose opinion he had sought, and nothing had been done except painting the skin over the swelling with iodine, which had had no beneficial effect. Things had gone on for a considerable time in this manner,

when on April 10th, suddenly, a fresh tumour appeared on the right side of the neck, over the collar-bone. This was accompanied by an increase of temperature in the parts, and the swelling showed considerable pulsation. At the same time alarming symptoms of pressure on the pneumogastric nerve became apparent, viz., loss of voice and of the power of swallowing, a sense of choking in the throat, and severe pain at the back of the head, on the right side. There was regurgitation of liquids through the nose, and the patient could not sleep, but was obliged to sit up in bed, propped up by pillows, or to lean forward in a chair.

Under these circumstances he had again consulted Sir William Fergusson, and implored him to operate. Sir William, however, declined to do so, and the patient was then sent to me by his usual medical attendant, Dr. Black, of Islington. I first saw him on April 13th, 1874, and found him in the following state:—The pulse was 120, respiration 36; anxious expression of countenance; eyes staring and protruding; excessive action of the left ventricle. He had not been able to sleep or eat for four days, and could only talk in a whisper. In front of the left side of the neck there was a tumour of the size of an orange, which was very hard, and showed no signs of fluctuation. It was limited interiorly by the thyroid cartilage and the windpipe, which were considerably displaced to the right side; exteriorly by the strongly pulsating carotid artery, superiorly by the horizontal branch of the lower jaw, and inferiorly by the apex of the trigonum supraclaviculare. On the right side there was a smaller but strongly pulsating tumour occupying the supraclavicular space. It was much softer and less prominent than the one on the left side. The circumference of the neck on the most prominent point of the left side was $16\frac{1}{4}$ inches, and on the right side $15\frac{1}{2}$ inches.

The patient was in such a state of prostration, and so

racked with pain and distress, that I thought it best to commence the treatment with an external application of the constant current, for the purpose of soothing and strengthening the nervous centres, and diminishing the effects of pressure upon the pneumogastric. He recovered his voice almost immediately, had some sleep the night after, and no more regurgitation of liquids. Next morning the expression was less anxious, the pulse had gone down to 90 beats, respiration 28; the voice went away and came again from time to time. On April 15th he reported that he had had four hours' sleep, eating had become easier, he had drunk off a whole tumblerful of beef-tea without trouble, and the voice was stronger. The tumour on the right side was smaller, and its pulsation much diminished. The headache was still intense, and did not seem to be affected by the external application of the current. On April 19th I introduced a needle connected with the cathode of 15 cells of Becker-Muirhead's battery into the tumour on the right side, and allowed the current to pass for fifteen minutes. On the 21st the patient reported that he had eaten solid food, and that the headache was nearly gone. The old tumour on the left side was now likewise attacked by electrolysis, to which after a time parenchymatous injections of the tincture of iodine were added. By the middle of May the tumour on the right side had entirely disappeared, and the left was then shrinking visibly under the influence of the treatment, which was continued, with some considerable intervals, until March, 1875. At that time there was only just a trace left to show that there had been once a tumour; and the circumference of the neck was reduced from $16\frac{1}{4}$ to $13\frac{7}{8}$ inches. Sir William Fergusson had an opportunity of examining him at that time, and expressed to me his gratification at the successful result of my treatment in a case which he had thought beyond surgical interference.

In cases where the enlargement of the thyroid body is

slight, the percutaneous use of the constant current is sufficient. Various methods have from time to time been used, the principal amongst them being general galvanisation and faradisation; the hydro-electric bath; the constant current to the neck ("cervical sympathetic") with the anode to the cervical spine, and the cathode "in stations" from the stylomastoid fossa down to the clavicula; or the anode to the fifth dorsal vertebra, and the cathode in stations along the whole spinal column; or with the anode on the solar plexus and the sternum. In addition to this the exophthalmus, the thyroid body, the heart, and any vertebræ which may be found tender, may be locally treated. Each particular application should be short and gentle, that is from a half to one minute, and 1 to 3 MA.'s, according to individual susceptibility, and the anode should as a rule have a larger surface than the cathode. A gradual introduction and cessation of the current are necessary.

Vigouroux and others have recommended faradisation of the neck, putting at first the anode of 7 to 8 scms. to the nape of the neck, and a small cathode of 1 scm. on the region of the superior cervical ganglion, leaving them on for one and a-half minutes on each side, with sufficient current-strength to cause contraction of the sterno-mastoid muscle, then acting on the motor points of the orbicularis palpebrarum muscle, the lids, and neighbourhood of the eyes; this is to be followed by the application of a somewhat large cathode to the supraclavicular space, the thyroid body, and the heart's region. The faradic current should be used in this way from ten to twelve minutes, on alternate days, and the treatment persevered with for months. The different modes of franklinisation have also occasionally proved useful.

Cardew has severely criticised these different methods of electrical treatment, and stated that there is in the works on electro-therapeutics "the most profound confusion, almost amounting to chaos, owing to the enormous number of

methods advocated." I cannot see any harm in there being a number of methods of treating such an obstinate complaint, as owing to constitutional differences in patients, which have always to be reckoned with, one method may fail in a given case, while another may prove beneficial. Cardew's criticism would therefore seem to be hardly called for, while the method he has proposed himself is not by any means free from objections. He advises patients who are for some reason unable to be under treatment by experts, to procure a small chloride of silver battery of four or six cells, and to apply the current themselves three times a day, with the anode of $3\frac{1}{2}$ inches in diameter, on the nape of the neck, while the cathode of $1\frac{1}{2}$ inches in diameter is moved up and down the side of the neck from the mastoid process along the course of the great nerves, for six minutes at a time. The method may therefore be described as "labile galvanisation of the cervical sympathetic," while almost every experienced electro-therapeutist uses the stabile method in that region, on account of the feelings of giddiness and other unpleasant sensations in the head, which interruptions of the current are apt to produce. Nor does Cardew say anything about the gradual introduction and cessation of the current, which are so important in such applications. The patient works without a collector, rheostat, or galvanometer, and the method would therefore certainly appear to be a "rough and ready" one, and might be attended with unpleasant results in sensitive persons. In spite of these drawbacks Cardew's proceeding seems to have done a great deal of good, which shows that electrical treatment is sometimes of advantage even where the usual rules of application are neglected.

Noises in the Head.

Tinnitus aurium, when loud and continuous, is most distressing, and usually depresses the mind and the whole nervous system of the patient in a marked manner. It is

exceptional that the sufferers get accustomed to the noise, and are able to follow the advice so freely tendered to them by their doctors and friends, that they should forget all about it, and think of something else; on the contrary, in the large majority of cases no amusement or change of occupation and scene has the slightest influence upon it, and the trouble is felt as keenly after it has lasted for years as it was when it first began. Persons who are otherwise well are better able to bear up against it than those in delicate health; but even a strongly tempered nervous system may eventually break down under the affliction.

Tinnitus is always produced by irritation of the auditory nerve, and this may be owing to local disease of the ear, or to certain more general conditions which have the tendency to cause modifications in the pressure of the endolymph which surrounds the expansion of the nerve in the labyrinth. It may occur from anything acting unfavourably on the nervous system, such as anxiety, grief, overwork, a sudden fright, or intemperance; and is seen particularly in the anæmic, the hysteric, and the neurotic generally, but also in others in whom it is impossible to discover a constitutional fault.

The fact that we are able, by a careful application of the constant current, to relieve a considerable proportion of cases of tinnitus, is either ignored or doubted in most of the best works on aural diseases. This unfavourable opinion of the authorities is probably owing to the circumstance that there are few complaints the successful treatment of which by means of electricity requires so much special knowledge of the physiological effects of that agent, such delicate adjustment of apparatus, and such technical skill in manipulating the same, as tinnitus of nervous origin; while, on the other hand, a haphazard application of electricity, even by those who are tolerably well acquainted with the other more common uses of the battery, is likely to do more harm than good; and the chance of thereby accomplishing a cure

must be considered as exceedingly remote. It is indeed astonishing to find such a distinguished aural surgeon as Politzer stating that the galvanometer and rheostat may be dispensed with in the application of electricity for the relief of aural affections.

I have fully described the proper mode of using the current for tinnitus elsewhere,[1] and related some striking cases in which benefit resulted from it, so that I would refer the reader to that publication for all further information on these points. Suffice it here to say that in general the stabile anode, used with from 1 to 5 MA.'s, for from five to twenty minutes, is the most effective application, and that particular care should be taken in diminishing the current-strength *gradually* at the end of the application, as sudden anode-opening has a prejudicial effect.

* * *

In certain otherwise intractable affections of the *abdominal and pelvic viscera*, electrical treatment is advisable after the failure of other therapeutical procedures.

Dilatation of the Stomach.

Where this is owing to obstruction of the pylorus, as is so often the case, no good results can be expected from the use of electricity. In a number of cases, however, its origin is neurotic, and then the constant and faradic current, as well as galvano-faradisation, may be usefully employed.

In November, 1887, Dr. Baumann, of Schlangenbad, sent to me a young lady, aged 16, who had eighteen months before suffered from jaundice and peritonitis. Two months before I saw her, she was rather suddenly taken with a cutting pain in the region of the stomach, which had never since then left her for a single instant. "She went to bed with it, and she woke up with it." At the same time she

[1] "On Tinnitus Aurium, and its Treatment by Electricity." London, 1887.

had noticed a swelling in the region of the stomach, which had gradually increased, and had now attained the size of about half a Seville orange. This swelling occupied part of the epigastrium, and part of the left hypochondrium, was extremely tender to touch and pressure, and gave on percussion a full tympanitic note. The whole neighbourhood of the tumour was highly sensitive, and touching it made her feel sick. There was loss of appetite and body-weight, and apart from the pain which was always present, she felt very weak and languid. The urine had a density of 1044, and contained an enormous excess of urea and urates, but no sugar or albumen. I treated the tumour with the stabile anode of 40 scms., 5 MA.'s for five minutes, and afterwards made cathodal passes over it. The first result of this treatment was relief, and presently complete cessation, of the pain and tenderness; and very soon afterwards the swelling began to subside. After thirty-three sittings every trace of it was gone, and the patient being then perfectly well, the treatment was discontinued. There has been no relapse.

Habitual Constipation.

I have treated a considerable number of cases of atony of the muscular coat of the bowel, leading to obstinate constipation, with both faradism and the constant current. The former is best applied with an insulated metallic cathode in the rectum, while a large anode is gradually conducted along the course of the large bowel. The primary is more useful than the secondary current. The constant current is also very effective, and should be used with a large anode on the lumbar spine, while a cathode of not less than 70 scms. is placed, and well pressed, on the region of the cæcum, where it should remain stabile for two minutes, after which it should act on the ascending, trans verse and descending colon. It is advisable to reverse the direction of the current from time to time (Voltaic alter-

natives), and the duration of the sitting should not be less than from fifteen to twenty minutes. It is sometimes useful to follow up galvanisation immediately by faradisation: and the combination of the two currents may likewise be employed.

Obstruction of the Bowels.

Intestinal obstruction is now generally treated by laparotomy, after purgatives, opium, and belladonna have failed; and there is no doubt that in the case of absolute mechanical occlusion, such as strangulation by bands, etc., the knife affords the only chance for the patient's recovery. Nevertheless, we are bound to admit that the risks of the operation are great, in spite of recent improvements in its *technique*; and for this reason it would appear preferable to resort to electricity rather than to laparotomy in cases where it is conceivable that the obstruction might be overcome by a powerful contraction of the muscular coat of the bowel, that is, in fæcal accumulation and intestinal palsy, foreign bodies impacted in the intestine, etc.

In January, 1878, Mr. Allingham requested me to see with him a gentleman, aged 54, who had on the whole been in fair health, but had for the last three months suffered from obstinate constipation, for which purgatives and enemata had been used without much effect. Nothing in the shape of a solid or liquid motion had been passed for fully ten days when I saw the patient. The abdomen was very much distended and tender; there was total loss of appetite, a degree of collapse, with sunken face, and a small and feeble pulse. Mr. Allingham had the day before introduced a long tube, but without bringing the fæces away, and was anxious that the effects of electricity should be tried, as the patient appeared to be in great danger. I introduced an insulated cathode with free metallic end, into the rectum, and applied a moistened conductor to the abdominal parietes, chiefly in the region of the sigmoid

flexure. The primary faradic current was now sent through, and its force gradually increased until the patient experienced a decided feeling of vibration throughout the bowel. The application was kept up for twenty minutes. This was done at 10 a.m., and the same evening the patient had a copious motion, with wonderful relief to all symptoms. During the next two days the bowels acted ten times, and in a week the patient appeared to be quite well.

Another case in which I have used faradism successfully was that of a married lady, aged 57, who had nearly all her life suffered from obstinate constipation, which she thought had been brought on "by living on biscuits at school." She had often gone for a week or ten days without relief, but did not appear to be much the worse for it until the time I was called in, when there was great distension and tenderness of the abdomen, bilious vomiting, and prostration after eight days' constipation.

I followed the same treatment as in the previous case, at 5.30 p.m. At 1 a.m. she had a good motion, followed presently by two others, when an enormous quantity of fæcal matters was discharged, with complete relief.

I regret to be unable to speak about the further progress of these cases, but in both of them life was evidently saved by the application of electricity.

"Electric Injections."

In France the continuous current has recently been somewhat extensively used in similar cases, more especially by MM. Boudet de Pâris and Larat, who have employed it in the form of so-called "electric injections." In order to avoid the escharotic effects of a metallic electrode applied directly to the mucous membrane of the intestines, salt water is injected into the rectum, so as to act as a large liquid electrode, the metallic conductor connected with the positive pole of the battery being enclosed in an elastic sound, and thus conducting the electricity to the salt water.

It is claimed that by acting in this manner a considerable current-strength can be safely used. The circuit is closed by placing a large negative electrode on the abdomen, when the deflection of the needle of the galvanometer indicates the passage of the current. The strength in MA.'s must be regulated according to the susceptibility of the patient. In many cases of pseudo-strangulation and fæcal obstruction, this proceeding, continued from five to twenty minutes, has appeared to give relief. In cases in which a real obstacle has to be overcome, it is recommended to use the current as directed for five or six minutes, and then to reverse its direction, care being taken first to reduce its strength, and get the needle of the galvanometer down to 0, after which the current is gradually put on again to its former power. As soon as the cathode acts in the rectum, the bowel contracts, and great desire is felt for defæcation, which the patient, however, is instructed to resist until he finds it impossible to do so any longer. One, two, or three such applications may be required in the twenty-four hours. M. Boudet states that he has been successful with "electric injections" in thirty-five out of fifty cases (70 per cent.), while M. Larat claims 101 successes in 230 cases (nearly 44 per cent.) The latter recommends resort to laparotomy at once if the electricity has failed to act in the period just mentioned, and not to lose time by exhibiting purgatives. If electric injections were made soon after the appearance of bad symptoms, and laparotomy followed quickly after failure of electricity, the electro-therapeutist as well as the surgeon would have a better chance of saving the patient's life than now, when they are often called in too late.

Paralysis of the Bladder.

In 1871, I brought the treatment of paralysis of the bladder by means of the constant current before the Annual Meeting of the British Medical Association, at

Plymouth, and related cases, in which I had used that treatment with benefit.[1] One of these was that of a married lady, aged 32, of highly nervous constitution, who had lived much in the tropics, and was sent to me by Dr. Frank in July, 1870. She had been very delicate as a child, and her mother had died of phthisis. Family troubles thoroughly upset a system naturally predisposed to nervous disturbance, and in which only some powerful exciting cause was required for the full development of hysteria. Early in 1870, when she was under the care of Dr. Siordet, of Mentone, the patient had cataleptiform seizures, and convulsive attacks resembling opisthotonos. She soon after lost her voice, and the power of walking and of voiding the urine. From March 6th, until the time she came under my care, the catheter had to be introduced twice daily. This was a cause of great inconvenience, for it became necessary that the patient should, in her travels, merely on account of this symptom, be constantly accompanied by a medical man able to give relief to the bladder. The urine in this case was quite normal. The labile cathode was used over the region of the bladder. After the first application, the patient passed her urine in a feeble stream, and with a certain amount of pain and straining; after the second application, she could pass it freely, and had fully retained the power of doing so when I last heard from her some years afterwards.

In the paper just mentioned I stated that it was neither necessary nor expedient to apply the current directly to the tissue of the bladder itself, as we might do by means of an insulated sound, with a free metallic end introduced into that organ. Direct galvanisation of the *full* bladder was objectionable, because a powerful chemical decomposition of the urine was the consequence of such a proceeding, giving rise to symptoms of fainting, owing to the sudden

[1] "On Paralysis of the Bladder and its Treatment by the Constant Galvanic Current." *British Medical Journal*, Nov. 8th, 1871.

distension of the viscus by the gases which are set free; while direct galvanisation of the *empty* bladder appeared to produce an irritating effect upon its mucous membrane. External galvanisation produced none of these inconveniences, and was often thoroughly effective, so that it should in all cases be employed in lieu of direct internal galvanisation.

Since then M. Boudet de Pâris has brought forward a new method of directly galvanising the bladder in the same manner in which the "electric injection" of the bowel is performed; that is to say, the electrode is introduced into the viscus protected by an elastic catheter, and then an injection of water or some medicated fluid is made, which serves as the active electrode, and carries the current to all parts of the mucous membrane and muscular coat of the bladder without the risk of cauterising the tissues. Where a percutaneous application of the constant current therefore should not answer, Boudet's "electric injection" may be used.

Electrical treatment has also been successfully employed in *nocturnal enuresis*, in certain forms of *impotency*, *spermatorrhœa*, and other affections of the genito-urinary tract, into which space prevents me from entering.

Amenorrhœa.

Amenorrhœa may, according to the causes by which it is produced and the circumstances of the patient, have a slight or a very considerable importance. In many cases it is only a symptom of insufficient sanguification, as when it occurs in chlorosis, phthisis, or after severe hæmorrhages or long-continued discharges which have exhausted the system. In such cases any local stimulation of the sexual organs for producing a menstrual flow would be improper, for the general condition, of which amenorrhœa is only an expression, must first be rectified where this is possible. Frequently the ovarian function is re-established simulta-

neously with the restoration of the general health. In other instances the catamenia may be suddenly stopped in consequence of a chill, fright, or anxiety; and the function may then remain in abeyance long after the cause by which it had been arrested has ceased. We can then no longer be sanguine that the menstrual flow will be restored by general treatment, and local stimulation of the sexual organs is generally found requisite for re-establishing menstruation.

Where amenorrhœa occurs in spinsters who are no longer likely to marry, or in married women who have already borne a number of children, the condition is not one of great importance; but where we meet with it in married and childless women, the case assumes a different complexion. When the catamenia are arrested, ovulation has likewise ceased, and the woman with amenorrhœa is therefore, as it were, prematurely unsexed; and the re-establishment of the flow then becomes of vital importance for the would-be mother. In cases of this kind, where the general health is often excellent, the usual treatment may fail to rouse the dormant function of the ovaries; and the various forms of electricity then step in as the right thing in the right place. The induction of catelectrotonus is probably the most effective way of applying electricity, although franklinic and faradic electricity have likewise been successfully employed.

A lady, aged 37, had had one full-grown but still-born child. She was very ill afterwards, and never saw any further trace of the menstrual discharge, although previous to her pregnancy she had always been perfectly regular. She underwent much treatment without any result, and Dr. Fordyce Barker, of New York, pronounced the case to be one of incurable atrophy of the ovaries. The patient eventually consulted Sir Spencer Wells, who discovered a slight degree of retroflexion of the uterus, which he replaced by the sound, and requested me to rouse the torpid condition of the ovaries by electrical treatment. A large

cathode was placed alternatively to the right and left ovarian region, while the anode was placed alternately to the lumbar spine and the os-uteri, and about 15 MA.'s were used for fifteen minutes consecutively. After a few such applications the patient felt the same sensations which she had usually had before the period came on, viz., persistent uterine pain and frontal headache. A slight mucous discharge from the womb commenced at the same time, and the patient fully expected that the catamenia would come. She was, however, then obliged to leave London, and I did not see her again until about four months afterwards, when she informed me that she had been disappointed in her expectation. The "sensations" had disappeared shortly after the treatment was discontinued, the uterine discharge had ceased, and the amenorrhœa persisted. The treatment was then resumed, and very soon afterwards the same "sensations" returned; while a thick mucous discharge from the womb came on, which was on one occasion sanguinolent. The electricity was now used thirty-three times, after which the menstrual flow appeared. For the first twelve hours it was quite as abundant as it had ever been before; it then diminished, and ceased soon afterwards, but a dark mucous discharge lasted two days longer. The first response of nature having been imperfect, I advised another short course of treatment previous to the time when the next period would be expected. She then had eight more applications, after which the period returned at the proper time, was of a particularly good character, and went on abundantly for four days. As therefore not only a satisfactory quality, but also decided periodicity of the ovarian function, had become established, the treatment was discontinued. Electrical treatment did more in this instance than all other means used by the most eminent gynæcologists had been able to accomplish.

Apostoli's Treatment of Uterine Tumours.

In 1867, when I brought my researches on electrolysis before the profession,[1] I treated a number of cases of myoma of the uterus electrolytically, but without any apparent success. I never used more power than about 15 MA.'s, and seeing that the tumours remained exactly the same as before, I discontinued my investigations of this point. A few other observers, more especially Tripier and Onimus, however, continued working on this subject; yet there appeared to be very little result until Apostoli, in 1882, was led to employ a far more considerable current-strength, viz., between 40 and 200 MA.'s, and by that means accomplished a considerable measure of success. He has indeed applied electricity with good results not only to the so-called fibroid tumour or myoma, but to many other affections of the womb and its appendages, and also to the diagnosis of inflammatory and suppurating lesions of the organ. As this subject is a very special one, which cannot be discussed in the limits of the space at my disposal, I would refer those who wish for full information about it, to the able articles by Grand and Famarque, and by Kellogg, which have appeared in Bigelow's "International System of Electro-therapeutics" (Philadelphia 1894).

Electrolysis of other Tumours.

When I first proposed the electrolytic treatment of tumours, operative surgery was not nearly as far advanced as it is at present, and in pre-Listerian times even small operations were sometimes followed by septicæmia and fatal results. I well remember a case in which one of the first surgeons of the day excised a small sebaceous tumour from the scalp of a lady, who died three days afterwards from

[1] "The Electrolytic Treatment of Tumours and other Surgical Diseases." London, 1867.

blood-poisoning caused by infection of the wound. Such things are now a matter of history, and as the operative technique has improved *pari passû*, the sphere of electrolysis, which has certainly the advantages of safety and bloodlessness, has become greatly limited. Yet there are tumours in which this treatment will have advantages over other surgical procedures; and amongst these I would particularly mention *nævus* and *sebaceous tumours*, in which the effects of electrolysis are truly admirable, and cannot be surpassed by any other means at our disposal. The same applies to

Tumours of the Eyelids.

In 1880 I treated a lady, aged 30, who suffered from tarsal tumours, occupying nearly the whole of both upper eyelids, more especially their inner surface, and which had gradually become developed without any apparent cause during the last six months. They looked inflamed, were very disfiguring, and caused great annoyance by interfering with the proper action of the lids. Mr. White Cooper, who was then known as a most dexterous operator, preferred electrolysis, of which we had had considerable experience together, to any other proceeding for the removal of the tumours, and sent the lady to me. Reflex action in the lids being very much increased, I operated with anæsthesia, and used my four-pointed electrolytic needle-conductors for the destruction of the tumours, which received the influence of the anode and cathode successively, with a current of about 4 MA.'s. In ten minutes the whole of the tumours, both inside and outside, were completely shrivelled up.

Not a drop of blood was lost at any stage of the operation, which was remarkable, especially when the highly-vascular sub-conjunctival portion of the tumour was treated. The patient recovered quickly from the influence of the anæsthetic, and went the same afternoon to her home in the country. I saw her again about a month afterwards, when

I found that the operation had been completely successful. The tumours had vanished, no scar was visible anywhere, and no eversion of the lids had occurred. Both eyelids had indeed a perfectly normal appearance.

Tarsal tumour is a troublesome affection and does not yield to external applications, such as the red precipitate or iodide of potassium ointment, so that if removal becomes necessary, free incisions have to be made, which are generally accompanied by much bleeding. The adhesive inflammation which supervenes upon the operation has sometimes to be increased by touching the interior of the cysts with nitrate of silver; and if the tumour be situated near the margin of the eyelid and the punctum, there may be cicatricial shrinking after the operation, and eversion of the edge of the lid, with displacement of the punctum. All this makes the ordinary operation for tarsal tumour a somewhat formidable one; and electrolysis, which is much simpler and easier, would therefore appear preferable. The complete absence of bleeding in the latter procedure is a great advantage, as the operator always sees what he is doing, and can regulate the action of the galvanic force with the greatest nicety. A single application is sufficient for a cure, and there is no danger of subsequent cicatricial shrinking, if the operation is properly performed.

Cancer.

Lawson Tait[1] has used electrolysis in a case of encephaloid cancer of the femur, in which the pain was so excessive that the patient had to be kept almost constantly under the influence of hydrate of chloral, morphine, and chloroform. After two electrolytic applications, the tumour was $\frac{3}{4}$ inch less than before, and there was such complete relief of pain that the patient required neither opiate nor chloral, and it was possible to lift her and change the bed-linen without the

[1] "Transactions of the Clinical Society of London," Vol. IV., p. 145.

administration of chloroform, which had not been done for three months previous to the second application of the electricity. After a few days the pain recurred, and another electrolytic operation was then made, after which she continued quite free from pain until her death, which took place from exhaustion and irritative fever about a week afterwards.

Epulis.

T. W. Nunn[1] has successfully treated cases of epulis with electrolysis, and states that the latter replaces with advantage a surgical operation which is more or less complicated, and always attended with considerable hæmorrhage, to say nothing of obviating the concomitants of a wound, which cannot from the circumstances of the case heal by first intention. In one of his cases the late Mr. de Morgan had operated on epulis of the lower jaw, when the hæmorrhage had been, if not alarming, at least considerable, both at the time of the operation, and for many hours afterwards. When epulis declared itself afterwards in the upper jaw, Nunn electrolysed the tumour with complete success, so that the patient was able to wear artificial teeth with great comfort and advantage.

Hydatid Tumours of the Liver.

Hilton Fagge and Durham[2] have brought before the Royal Medical and Chirurgical Society an account of six cases of hydatid tumours of the liver which were under their care at Guy's Hospital, and in which they carried out my suggestion that these tumours should be treated by electrolysis. Their first case was that of a girl aged 7, who had a hydatid tumour of the size of a cocoanut, occupying the whole thickness of the liver. A single application of the negative needle was sufficient for the cure of the

[1] "Transactions of the Clinical Society of London," Vol. XI., p. 157.
[2] "Medico-Chirurgical Transactions," Vol. LIV., p. 1.

tumour, and this satisfactory result induced Fagge and Durham to use it in five other cases, with equally beneficial effects. Cooper Forster has been successful with the same treatment in two other cases, and Fagge and Durham claim for this method the following advantages: 1, that the operation itself is altogether free from danger, and 2, that it is not liable to set up suppuration within the cyst, and thus indirectly to involve the patient in serious risk.

Facial Blemishes.

In 1867 I removed by electrolysis a very unsightly hairy mole from the face of a well-known London physician; and in 1868 I used the same proceeding for destroying superfluous hair on the face of a lady who was very much disfigured by the growth. This proceeding has subsequently been much taken up in America, where Michel, of St. Louis, used it for trichiasis, and Hardaway, Fox, and others have extended its employment to other cutaneous affections.

Superfluous hair on the face of ladies, when amounting to moustaches or whiskers or beards, is a great eyesore, and often induces them to retire from society and lead a solitary and miserable life, in which they are apt to brood over their misfortune. There are no really good chemical depilatories by which the hair can be radically removed without leaving a scar on the face, and Erasmus Wilson used to say that the only trustworthy depilatory was the razor. Shaving, however, does not satisfy women who are annoyed by this trouble, and it is therefore fortunate that we possess in electrolysis a perfect and radical depilatory. When the hair follicle is once carefully destroyed by the action of the negative pole, no further growth is possible, and no scar is left.

The electrolytic removal of hair is one of the most delicate operations in electro-surgery, and requires for its proper performance a considerable amount of skill, practical

experience, and attention on the part of the operator. The principal rules which have to be observed for this little operation are as follows :—

1st, Each hair must be done singly.

2nd, Only the negative pole may be employed for destroying the hair-follicle, and the circuit should be closed by a moistened anode held in the patient's hand.

3rd, An exceedingly fine gold needle should be used for introduction into the follicle.

4th, The current should only begin to act after both electrodes are *in sitû*, and must be broken before the needle is removed.

5th, A feeble but absolutely constant current should be used. For fine hairs 1 MA. is the best strength, but where the hair is thick and coarse, 1·2 to 1·4 MA.'s may be employed. The current-strength must be read off from a thoroughly reliable horizontal galvanometer, and this should be carefully watched while the current is acting, as the resistance diminishes all the time, and we may therefore presently have 1·5 instead of 1 MA.

6th, Sixty seconds are habitually sufficient for destroying a follicle; but where the hair is very thick, seventy or eighty seconds may be required.

7th, After the follicle has been destroyed, the hair should be extracted by tweezers, and should come out almost by itself. If any resistance is experienced the current must be put on again for another twenty seconds, and a fresh attempt at extraction made, when the hair will come out without much pulling.

No dressing is required after the operation.

The sitting should not be prolonged beyond fifteen or at most twenty minutes, as after that the attention of the operator is apt to flag.

If the above rules are strictly followed, the result will be satisfactory. At first the part of the face which has been operated upon appears red and feels hot, and for a few

weeks a slight mark shows the place where the current has acted. This, however gradually fades away, and becomes imperceptible.

I have had some ladies under my care whose beards were truly appalling, and where the face became eventually quite honeycombed with punctures of the electrolytic needle, yet after a time the beard as well as all traces of punctures had disappeared, and the face had resumed its normal appearance.

Chilblains.

Although an apparently insignificant affection, chilblains may be a great trouble, as they give rise to an amount of itching, smarting and burning, which may be well-nigh unbearable. This trouble, which is not confined to children, often begins early in the autumn, and may last throughout the winter, and it obliges the sufferer to keep very quiet, as walking increases the discomfort. Chilblains often resist treatment intended to relieve the inflammation, but yield readily to the application of the labile cathode. A large anode should be placed at some distance from the seat of the inflamed surface, after which cathodal passes are made over the erythematous patches. The current-strength has to vary according to the seat of the chilblains and to the susceptibility of the patient. For the fingers, toes, ears, and nose, 1 to 1·5 MA.'s will be generally sufficient, while at the heel as much as 8 or 10 MA.'s may be required. There is generally immediate relief, and after a few applications, entire cessation of the trouble.

Raynaud's Disease, Erythromelalgia.

In these affections, which are closely allied to chilblains, but of a more severe character, there is no better remedy than the constant current, administered either by cathodal passes over the affected parts, or by means of a local bath,

in which the affected limbs may be immersed. In the latter case the large anode should be placed above the seat of the trouble, and the cathode in the water, interruptions being made from time to time in the metallic circuit.

Rheumatism.

In rheumatism of the muscles, and chronic rheumatism of the joints, electrical treatment is in general very effective. The most frequent form of muscular rheumatism in this country is *lumbago*. I have treated a very large number of cases of it in which the use of faradic as well as galvanic electricity proved rapidly effectual in relieving the pain and discomfort from which the patients suffered. The stabile anode, followed by cathodal passes, and faradisation of the skin with the wire-brush, are the best proceedings. The same treatment is effectual for *torticollis*.

In stiffness of the joints after rheumatic fever the constant current may be very beneficial by its catalytic effects in promoting the absorption of effusions, and restoring the mobility and proper use of the joints. It is important in the treatment of such conditions to change the poles from time to time and to pass the current through the joint in different directions. Thus the knee-joint should be treated by the stabile anode in front, and the cathode at the back, of the joint for one minute; then the current is turned off, its direction reversed, and its passage renewed. The anode is then placed to the right, and the cathode to the left side of the joint, the current passed for a minute, and the direction once more reversed. After this it is passed diagonally in two different directions, and the application is finished by stabile and intermittent applications to the neighbouring nerve-trunks and muscles. In obstinate cases the nutritive centre of the knee-joint in the lumbar enlargement of the spinal cord should also be acted upon.

Rheumatoid Arthritis.

In 1872, I advised, in a paper read before the Annual Meeting of the British Medical Association, at Birmingham,[1] a systematic treatment of rheumatic gout by the aid of the constant current. In that paper I recommended a modified form of general galvanisation, and concluded by saying that "those who will not shirk the sometimes rather tedious labour involved in carrying out such a treatment perseveringly, will ultimately be amply rewarded for their trouble by an amount of success which, in some forms of the disease, could not have been obtained by any other line of treatment." Subsequently similarly good results have been gained in this disease by Steavenson, who advocated chiefly the employment of the hydro-electric bath; by Armstrong, who combines the use of the hydro-electric bath with treatment by the Buxton waters, and by Lewandowski, who uses a proceeding similar to that first recommended by myself.

[1] "On the Treatment of Rheumatic Gout by the Constant Galvanic Current." *British Medical Journal*, Sept. 28th, 1872.

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